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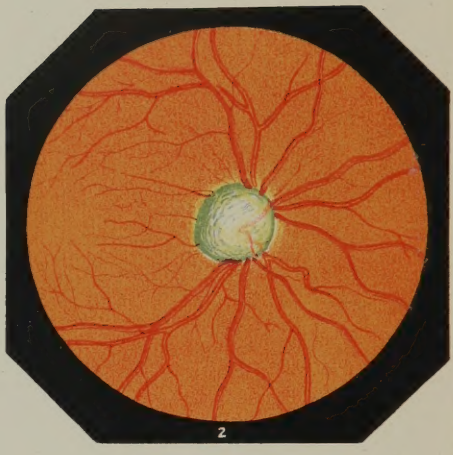
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DESCRIPTION OF THE CHROMO-LITHOGRAPHS.

PLATE I.

FIG. 1.—Semi-schematic representation of the papilla of an eye which is myopic in a moderate degree. The colored plate is taken from nature; the lower gives a schematic section of the same optic nerve. (Landolt, Refraction and Accommodation of the Eye, page 427.)

P N, crescent; *P P'*, pigmented circle, corresponding to the choroidal ring; *N*, outline of the optic nerve; *S*, super-traction of the inner part of the retina; *V*, vein passing over it; *H*, hilus of the central vessels, covered by the overlapping retina. The inner and outer sheaths of the optic nerve are noticeably separated from each other.

FIG. 2.—Normal fundus oculi in an individual with light-brown hair. (Jaeger, Beiträge zur Pathologie des Auges., Taf. I.)

FIG. 3.—Upright image of an astigmatic eye. (Ophthalmoskopischer Hand-Atlas von Eduard von Jaeger. Neu bearbeitet von Dr. Maximillian Salzmann, Taf. V., Fig. 31.)

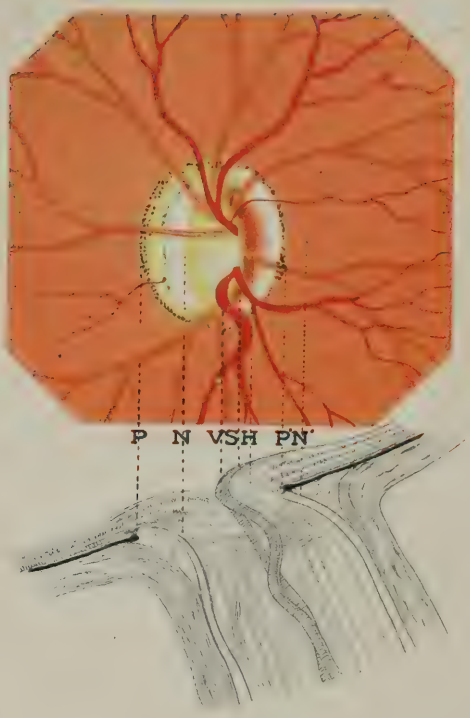
PLATE II.

FIG. 1.—Congenital excavation of the nerve-head. (Jaeger, *loc. cit.*, Taf. XI.)

FIG. 2.—Glaucomatous excavation of the nerve-head. (Jaeger, *loc. cit.*, Taf. XIX.)

FIG. 3.—Optic neuritis (papillitis). Right optic disc of a patient suffering probably from a cerebral tumor. (Gowers's Medical Ophthalmoscopy, Pl. I., Fig. 6.)

FIG. 4.—Atrophy of the optic nerve; right eye. The duration of the disease was three years. The patient presented slight spinal symptoms. (Gowers, *loc. cit.*, Pl. II., Fig. 6.)


P N V S H P N'


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DISEASES

OF

THE EYE.

A HAND-BOOK OF OPHTHALMIC PRACTICE,

FOR

STUDENTS AND PRACTITIONERS.

BY

G. E. DE SCHWEINITZ, M.D.,

PROFESSOR OF DISEASES OF THE EYE IN THE PHILADELPHIA POLYCLINIC; LECTURER ON MEDICAL OPHTHALMOSCOPY IN THE UNIVERSITY OF PENNSYLVANIA; OPHTHALMIC SURGEON TO THE PHILADELPHIA HOSPITAL, AND TO THE CHILDREN'S HOSPITAL; OPHTHALMOLOGIST TO THE ORTHOPÆDIC HOSPITAL AND INFIRMARY FOR NERVOUS DISEASES.

WITH

TWO HUNDRED AND SIXTEEN ILLUSTRATIONS AND TWO CHROMO-LITHOGRAPHIC PLATES.

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PREFACE.

This book has been written in the hope that it may prove of service to students and practitioners who desire to begin the study of ophthalmology.

The methods of examining eyes, and the symptoms, diagnosis and treatment of ocular diseases have received the largest share of attention. The subject-matter has been given in greater detail than is customary in books written for students, because the author has been led to believe by those whom he has had the privilege of instructing in the Medical Department of the University of Pennsylvania, in the Philadelphia Polyclinic, and in the wards of the Philadelphia Hospital, that this presentation of the practice of ophthalmic science and the systematic examination of cases would be acceptable.

Certain illustrations, descriptions, and classifications taken from standard text-books and monographs, which have proved of special service in teaching students, have also been incorporated. These are properly acknowledged in the text, and a list of the books and brochures which have been constantly consulted during the preparation of these pages is also appended. Some previous writings of the author—Affections of

the Eyelids, Lachrymal Apparatus, Conjunctiva, and Cornea, in Keating's Cyclopædia of Diseases of Children, Vol. IV.; Congenital Anomalies of the Eye, in Hirst's System of Obstetrics, Vol. II.; and Diseases of the Eye (Revision of the chapter) in Ashhurst's Principles and Practice of Surgery (Fifth Edition)—have also been utilized.

Dr. James Wallace, Chief of the Eye Dispensary of the University Hospital, has written Chapters I. and IV.; that portion of Chapter III. which relates to reflection, the ophthalmoscope and its theory, and the explanation of the direct and indirect method; and that part of Chapter XIX. which describes the mechanism of diplopia, the rotation of the eyeball around the visual line, and the causes of concomitant convergent and divergent squint. He has also given valuable advice and assistance in reading the sheets for the press. Dr. Edward Jackson, Professor of Ophthalmology in the Philadelphia Polyclinic, has written the section on Retinoscopy. The author is indebted to these gentlemen for their aid, and for the presentation of the subjects entrusted to them in a manner which, he feels sure, will be satisfactory to students.

Messrs. J. H. Gemrig and Son have very kindly furnished the cuts of the instruments which illustrate the chapter on Operations.

Philadelphia: 1401 Locust St.,
March, 1892.

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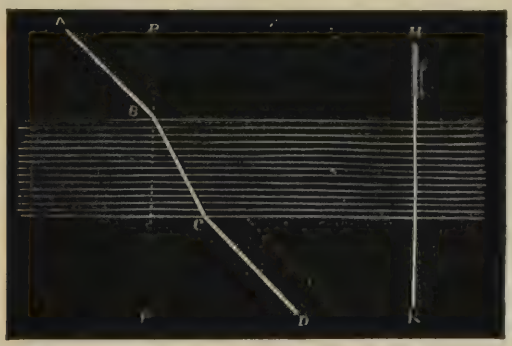
GENERAL OPTICAL PRINCIPLES.

BY JAMES WALLACE, M.D.

Refraction.—By refraction of light is meant the alteration which takes place in the direction of luminous rays, which pass obliquely from one medium into another of different density.

A ray of light passing through air maintains an undeviating direction until it encounters some denser medium whose surface

Fig. 1.



Refraction of light through a plate of glass bounded by plane surfaces which are parallel. *A B* is the incident ray, *B C* the same ray, refracted by the first surface, nearer to the perpendicular *P P*. *C D* the same ray, refracted by thesecond surface, becomes parallel to *A B*, its original direction. The ray *H K*, perpendicular to the surfaces *B* and *C*, undergoes no refraction.

lies obliquely to the incident ray. The course of the ray is now changed so that it assumes in the denser medium a direction nearer to the perpendicular to its surface. If the medium is a

piece of glass, bounded by parallel sides, the ray, as it passes through the second surface, is bent back again into the rarer medium.

Rays passing from a denser into a rarer medium are deviated from the perpendicular. The ray now has a direction parallel to its original course; the sides being parallel, the deviation at each surface is equal in extent, but opposite in direction.

Fig. 2.



Refraction through a denser medium having oblique surfaces. At each surface the ray is bent towards the base of the figure.

If the denser medium is bounded by oblique surfaces, the deviation at the second surface does not restore the ray to its original direction; but it still more increases the alteration.

Index of Refraction.—The deviation of the ray from its course depends upon the difference in the density of the two media.

A ray passing obliquely from one medium into another of the *same* density is not bent from its course. The relative density of any substance is expressed by its *index of refraction.*

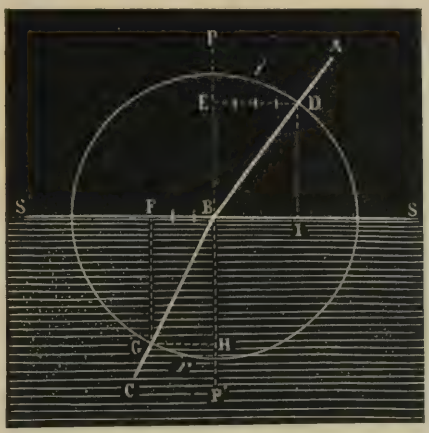
The absolute index of refraction is the density of any substance compared with a vacuum. As there is very little difference between the indices of refraction of air and a vacuum, air is considered as 1 for all calculations in lenses. Moreover, air is one of the media in the relations of lenses to the eye.

As the difference in the density of the two media increases, the ray is bent more sharply from its course, and the angle it forms with the perpendicular after refraction by a denser medium, is proportionably smaller than the angle formed by the ray before refraction.

The angle formed by the ray with the perpendicular to the

surface of the second medium is called *the angle of incidence*, angle i. The angle formed by the ray with the perpendicular after refraction is called *the angle of refraction*, angle r. The sine

FIG. 3.



$E\ D$ sine of the angle of incidence. $G\ H$ sine of the angle of refraction. (Landolt.)

of the angle of incidence divided by the sine of the angle of refraction gives the index of refraction. The mode of calculating this is shown in the figure.

An incident ray $A\ B$ strikes the surface $S\ S'$, forming the angle of incidence $A\ B\ P$ with the perpendicular $P\ P'$. It is refracted by the surface $S\ S'$, and passes into the second medium ; but its course is now changed to the direction $B\ G$, nearer the perpendicular than before. The angle $C\ B\ P'$ is the angle of refraction. If, now, a circle is drawn around B, as a centre, and at the points D and G perpendiculars are drawn to the line $P\ P'$, the line $E\ D$ will be the sine of the angle of incidence, and the line $G\ H$ will be the sine of the angle of refraction. The index of refraction is found by dividing $E\ D$ by $G\ H$, $\frac{E\ D}{G\ H} =$ index of refraction. In this case $E\ D = 4$, and $G\ H = 3$ ($F\ B = G\ H$). The index of refraction of the medium is $\frac{4}{3} = 1.33$ times that of air.

It is evident from this that the sines of the two angles are inversely proportional to the indices of refraction of their respective media.

$G\ H = 3$. $E\ D = 4$. Index of first medium, air, $= 1$. Index of second medium $= 1.33$.

$G\ H : E\ D :: 1 : 1.33$.

The following table from Landolt contains the index of refraction of some of the principal substances. The index of refraction of the glass used in spectacles is about 1.53.

Table of absolute indices of refraction from Landolt.

I. SOLIDS.	
Crown glass	1.5
Flint glass	1.57 to 1.58
Ice	1.310
Rock crystal	1.562
Quartz (ordinary index)	1.547
Diamond	2.48 to 2.75
Cornea	1.3365
Crystalline lens, cortical layer	1.393
" " intermediate layer	1.419
" " nucleus	1.431
II. LIQUIDS.	
Water	1.336
White of egg	1.351
Human blood	1.354
Sulphuric ether	1.358
Rectified alcohol	1.372
Canada balsam	1.532
Saturated solution of sea salt	1.575
Bisulphide of carbon	1.678
III. GASES.	
Air	1.000294
Oxygen	1.000272
Nitrogen	1.000300
Carbonic acid	1.000439

Prisms.—In order to be refracted a ray of light must also form an angle with the perpendicular to the surface of the medium of different density. Rays which strike the surface perpendicularly pass through without deviation. This is best understood by considering prisms.

A *prism* is a portion of glass, or other transparent substance, included between two plane surfaces which are inclined to each other. The angle formed by the two surfaces is called the *refracting angle* of the prism, and is expressed in degrees. Formerly prisms were designated by the number of degrees in the refracting angle.

Apex and Base of the Prism.—The sides converge to a thin edge at one extremity of the prism. This is called the *apex*. At the other extremity they diverge from each other forming the *base*.

The position of a prism is described by the direction in which its base is situated; thus, base up means that the prism is to be held in front of the eye, or ground into a spectacle glass, with the base or thickest part of the prism above; in like manner the expressions base down, base in, or base out indicate that the base is placed in one of these positions.

Refraction Through a Prism.—A ray of light falling upon the surface of a prism is bent towards the perpendicular (Fig. 4).

A glance at the figure shows that the perpendicular to the surface of a prism is inclined towards the base. The ray, therefore, is directed towards the base, and passing across the prism falls upon the surface of the air bounding it. The perpendicular is here directed away from the base, but the ray passing into air is deviated from the perpendicular, and consequently approaches still closer to the base. The refracted ray, therefore, is always deviated towards the base of the prism.

Fig. 4.



Deviation produced by a prism (Jackson). I, angle of incidence. R, angle of refraction. D, angle of deviation. $R + D = I$. D equals in weak prisms about ½ of R.

To the eye of an observer placed at the other side of the prism the refracted ray seems to come from the direction of the apex, since a ray is projected backwards over the course given to it by its last refraction, and a single object appears double if with both eyes open a prism of sufficient strength is placed before one of them. The angle which the ray in this last direction forms with the ray in its original direction is called the *angle of deviation*.

When one eye on account of muscular weakness is unable to direct its visual line to the point of fixation, a prism will alter the direction of the ray from the point of fixation so that it coincides with the visual line of the weaker eye. The refractive properties of a prism are further utilized to test the strength of

the ocular muscles (see page 76) to neutralize the diplopia caused by abnormal deviation of the visual line, for example, in strabismus, and to detect malingerers who feign monocular blindness (see page 485).

Angle of Deviation.—The angle of deviation is the angle formed by the incident ray with the refracted ray. The amount of this angle is nearly one-half of the refracting angle of the prism for all prisms between 1° and 10°. Above this the deviation rapidly increases.

When the angle of incidence, formed by a ray in the interior of a prism, amounts to 40° 49′, the angle of refraction equals 90° ; the angle of deviation, the difference between the two, then equals 49° 11′. The refraction which takes place at each surface of the prism must be considered in determining the amount of the deviation. When this is equal at the two surfaces the minimum amount of deviation is present. When the ray is perpendicular to one surface the angle of incidence, at the second surface, equals the angle of the prism ; and the deviation is greater in this case, as all the refraction takes place at one surface. A table of the minimum deviation of prisms is given below.

Limit-Angle of Refraction.—The greatest angle which a ray can form with the perpendicular is 90°. If the incident ray forms this angle, it can still enter the glass at an angle of 40° 49′. This is the *limit-angle of refraction.*

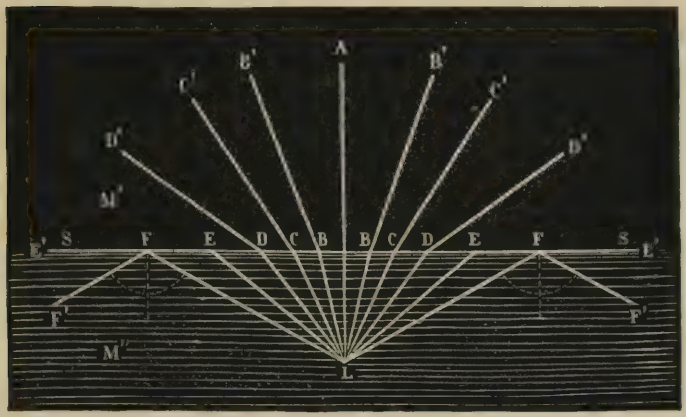
In the same way rays in glass forming an angle of 40° 49′ pass out into air, but if they form a greater angle than this, they are reflected back again into the glass and do not pass out. This phenomenon is called *total reflection* (Fig. 5).

Internal Reflection.—Rays may undergo a series of reflections inside a prism until they finally strike the surface at such an angle that they pass out. A pair of prismatic spectacles in this way gives rise to a multiplication of images by means of rays which suffer internal reflection before they emerge from the lens. Thus they are projected in different positions from the object.

Numbering of Prisms.—The designation of prisms by their angular deviation, instead of by their refracting angles, was urged by Dr. Edward Jackson, of Philadelphia, before the Ninth

International Medical Congress. Two methods of accomplishing this have been proposed :—

Fig. 5.



The limit-angle of refraction (Landolt). The rays from the point *L*—*L A*, *L B*, *L C*, *L D*, *L E*—pass out of the denser medium with increasing angles of refraction. *L E*, refracted as *E E'*, parallel to the surface *S*, forms the limit-angle for rays which still emerge. The ray *L F* is reflected back to *F''*.

Dennett's Method: The Centrad.—Dr. William S. Dennett's calculation has for its base an arc called the *radian*, whose length equals the radius of its curvature. Such an arc equals 57.295°. A prism which will produce an angular deviation of the one-hundredth part of this arc is called *one centrad*. The deviation of such a prism would therefore be .57295°. The merit of this method consists in the uniformity of the deviation, ten centrads having exactly ten times the deviation of one centrad. The deviations are so many hundredths of the radius measured on the arc.

Prentice's Method: The Prism-Dioptre.—Mr. Charles F. Prentice proposes, as the standard of deviation, a prism which shall deflect a ray of light one centimetre at a plane one metre distant; that is, the hundredth part of the radius measured on the tangent. This he calls the *prism-dioptre*. The value of the centrad and prism-dioptre will be given below. (See table.)

There are two practical advantages connected with the method

of Mr. Prentice which also can be applied to the centrad. The prismatic deviation of a decentred lens may be very readily found, as Prentice has shown, by the following rule: If a lens be decentred one centimetre, the prismatic deviation of the lens will be equal to as many prism-dioptres as the number of dioptres in the lens. Thus, if a 4-dioptre lens be decentred one centimetre, the prismatic deviation will be 4 prism-dioptres, or 4 centrads, since centrad and prism-dioptre almost exactly equal each other. The same lens decentred one-half centimetre would produce 2 prism-dioptres or centrads of deviation.

The relation to the metre angle (page 54) is also very simple. One-half the interpupillary distance is the sine of the metre angle. The ratio of this to the point of fixation in hundredths gives nearly the number of prism-dioptres, or centrads of deviation, embraced in any number of metre angles. For example, if the interpupillary distance is 60 mm., one-half of this is 30; assuming the amount of convergence to be 4 metre angles, 25 centimetres, or 250 mm., is the distance of the point of fixation. The deviation of the visual line then is 30 in 250, or 12 in 100 = 12 centrads, or 12 P. D. For small arcs the tangent and the sine agree very closely with the arc. Four metre angles of convergence then represent 12 centrads of deviation, or 12 prism-dioptres.

Table of relative values of centrads and prism-dioptres.

Centrads.	Prism-dioptres.	Refracting angle of prism required.
1	1	1.06°
2	2.0001	2.16
3	3.0013	3.24
4	4.0028	4.32
5	5.0045	5.40
6	6.0063	6.47
7	7.0115	7.54
8	8.0172	8.62
9	9.0244	9.68
10	10.0333	10.73
15	15.114	16.1
20	20.270	21.13
40	42.288	39.0073

The prisms represent the minimum deviation with an index of refraction of 1.53.

Rays of Light.—Any luminous point diffuses light in all directions in straight lines called *rays*. As the rays proceed from the luminous source those which diverge from one another become more widely separated. (Fig. 6.)

Fig. 6.



Divergence of rays from a luminous source (Loring).

If a circular aperture one centimetre in diameter be made in a metal plate, and a luminous point be placed at different distances from it, for example, at one metre and at ten metres, the rays coming from ten metres, which pass through the aperture, will be less diverging than those which come from one metre. A cone of light will pass through the aperture in each case, but the shape of it will be different according to the distance of the light from the aperture in the screen. When the round hole, 1 centimetre in diameter, is 1 metre distant from the point of light, the cone has a base 1 centimetre in diameter, and the apex is situated in the luminous point 100 centimetres distant. The rays have diverged 1 centimetre in travelling 100; the metal plate has cut off all other rays having a greater divergence. If the cone of light passes through the aperture and falls upon a distant wall, the cone will preserve the same proportions, viz., the base will be $\frac{1}{100}$ of the altitude. If the wall be 5 times the distance of the screen from the light, a luminous circle 5 centimetres in diameter will be formed upon the wall. If, now, the light is removed to a point 10 metres from the screen (1000 centimetres), a cone of light is formed whose base is 1 centimetre and whose altitude is 1000. The rays which pass through the aperture have now only $\frac{1}{10}$ of the divergence of the rays in the former case; the base of the cone is $\frac{1}{1000}$ of the altitude. The cone of light will now form a circle on the wall 5 metres distant from the light, only 1.5 centimetres in diameter. If the point of light be at a very great distance, there will be no difference in the size of the luminous circle and the aperture in the screen; the size

of the circle remains 1 centimetre, no matter how far the wall may be from the screen. The rays must, therefore, have a parallel direction. This is shown in Fig. 7.

Fig. 7.

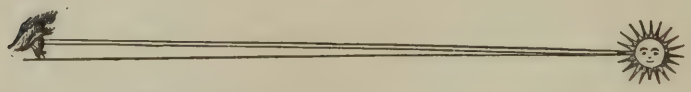


Rays diverging from the candle *A* pass through the aperture in the screen *S*, and form the cone of light whose base is the distance *a a'*. Rays from a more distant candle *B*, having a greater divergence than *b b'*, are intercepted by the screen *S*.

Rays which enter the pupil of the eye from a point 6 metres distant have so little divergence that they may be considered parallel. The average size of the pupil being 4 mm., the divergence is only $\frac{4}{6000}$. All rays diverging more widely than this are excluded by this width of the pupil.

There is no perceptible difference to the eye between rays diverging from 6 metres and those coming from an infinite distance, but for lenses of long focal distance and large aperture an infinite distance is required in order to obtain parallel rays. The sun and stars are so remote that the rays coming from them have no appreciable divergence, and they are considered parallel.

Fig. 8.



Showing how distant rays become parallel (Loring).

Parallel Rays.—Parallel rays are brought together by a lens at its principal focus; conversely, rays which diverge from the principal focus of a lens are parallel to one another after being refracted by the lens. As parallel rays must emanate from a distant object, any eye which brings parallel rays to a focus is

adapted for distant vision, and if its accommodation is relaxed is *emmetropic*. When light passes from such an eye from within outwards the rays are parallel.

Divergent Rays.—Rays which diverge from one another require more refraction to bring them together at the same distance behind a lens, than rays which are parallel; consequently, divergent rays are brought together at a farther point than the principal focus. The nearer the point of divergence lies to the lens, the farther away from the lens is the point where the rays converge to a focus.

Convergent Rays.—Only those rays converge to a common point which have passed through a convex lens, or have been reflected from a concave mirror.

Significance of the Different Rays.—The refraction of the eye is determined by the character which the rays must have in order to be brought to a focus on the retina.

An *emmetropic* eye, with relaxed accommodation, requires rays to be parallel in order that they shall meet on the retina.

A *myopic* eye requires the rays to diverge from some near point in order to meet on its retina.

A *hypermetropic* eye requires rays which already have convergence to some point in order to unite them on its retina.

An emmetropic eye emits parallel rays.

A myopic eye emits convergent rays.

A hypermetropic eye emits divergent rays.

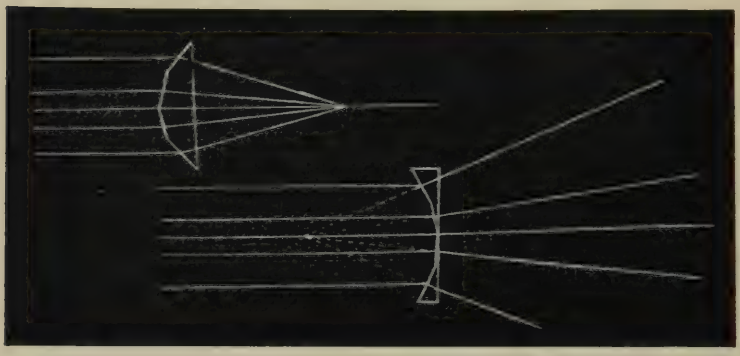
Lenses.—A lens is a portion of glass, or other transparent substance, bounded by two curved surfaces, or by one curved surface and one plane surface. The curved surfaces are convex, elevated in the centre and thin at the edge; and the concave, hollowed out in the centre and thick at the edge.

A lens may be regarded as a series of prisms with the refracting angles increasing in value from the centre toward the periphery.

In a *convex* lens the bases are directed towards the centre of the lens, and rays, therefore, are refracted towards the axis which passes through the centre. In a *concave* lens the bases of the prisms are directed away from the centre, and rays, therefore, are refracted away from the axis. As the angles increase from the centre outwards, the peripheral rays will be refracted more than the central rays. The result of this is that in a convex lens the

rays after refraction converge to the same point, the increased bending of the more peripheral rays just sufficing to compensate for their greater distance from the axis. In a concave lens the

Fig. 9.



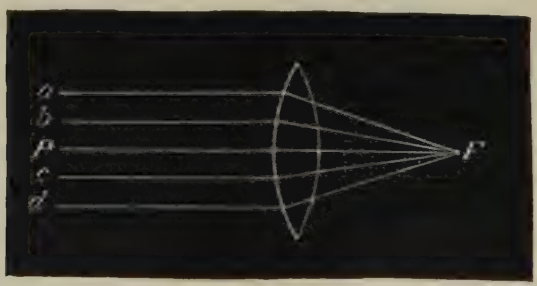
Lenses as prisms.

rays diverge more widely as they pass through the peripheral parts of the lens, with the result of making them appear to have diverged from a common point.

Focus of a Convex Lens.—The point to which rays converge after refraction by a convex lens is called its *focus*.

Principal Focus of a Convex Lens.—The principal focus of a lens is the focus for parallel rays. As the most distant rays are

Fig. 10.



Principal focus of a convex lens. The parallel rays, *a*, *b*, *c*, *d*, are refracted by the lens so as to unite at the point *F* on the axis *P*; the ray *P* undergoes no refraction. *F* is the principal focus.

only parallel, never convergent, the principal focus is the shortest focus, unless the lens be combined with another convex lens, or concave mirror. Rays diverging from the principal focus of a lens are rendered parallel after passing through the lens, and come to a focus at an infinite distance.

Conjugate Focus of a Convex Lens.—When rays diverge from any point nearer than infinity, they are brought together at a point on the other side of the lens farther than the principal focus. The point from which rays diverge and the point to which they converge are called *conjugate foci.* As the point of divergence approaches the lens the point of convergence recedes; when the point of divergence is at twice the focal distance of the lens, the point of convergence is at an equal distance on the other side. The *conjugate foci* are now equal.

As the point of divergence approaches still closer, the point of convergence is at a greater distance, until when the point from which the rays diverge is at the principal focus the rays converge at an infinite distance.

Fig. 11.



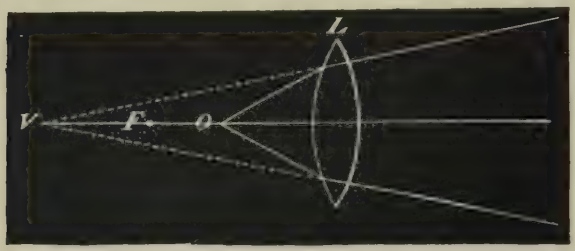
Conjugate focus of a convex lens. The two dots in the axis represent the principal foci, one being marked *F*. Rays diverging from *O* converge after refraction to the point *F'*, farther than the principal focus. Rays from *F'* also converge after refraction to *O*. *O* and *F'* are conjugate foci.

Rays diverging from either of these points converge towards the other. When rays diverge from a point whose distance is equal to, or greater than, the principal focus, the conjugate focus is *positive.* When the distance is less than the principal focus, the conjugate focus is *negative.*

Virtual Focus of a Convex Lens.—When rays diverge from some point nearer to a lens than its principal focus, the rays

after refraction still continue divergent. These divergent rays, if traced backwards, would meet in a point on the same side of the lens from which they diverged. This point is called a *negative*, or *virtual* focus, because the rays do not really meet here, but are given a direction by the lens as if they had diverged

Fig. 12.

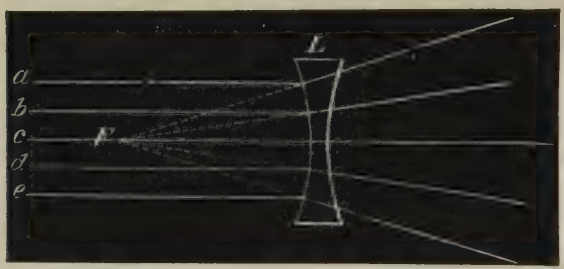


Virtual focus of a convex lens. Rays from the point *O*, less than the principal focal distance, diverge after refraction as if they came from the point *V*. *V* is the virtual focus of *O*.

from this point. (Fig. 12.) Therefore, the point from which rays diverge, and the point to which they converge, are focal points.

Foci of Concave Lenses.—The foci of concave lenses are

Fig. 13.



Principal focus of a concave lens. Parallel rays *a*, *b*, *d*, *e*, after refraction by the concave lens *L*, are rendered divergent as if they came from the point *F* on the axis *c*. The ray *c* is not refracted. *F*, the principal focus of a concave lens, is virtual.

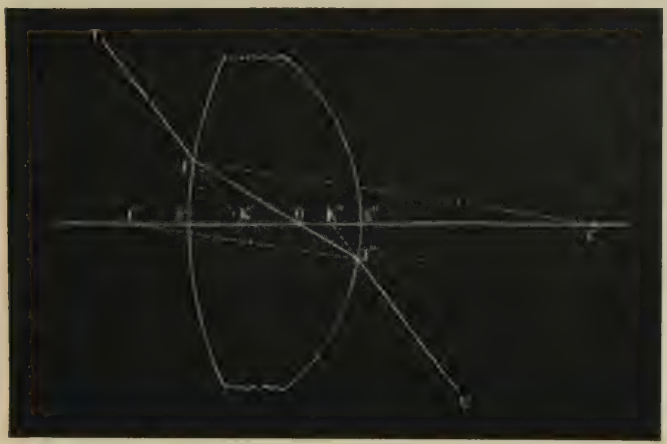
all virtual, or negative. They are found by projecting the divergent rays backwards until they unite in a point.

Principal Focus of a Concave Lens.—When parallel rays fall upon a concave lens they are rendered divergent. If these rays be traced backwards, they will seem to have diverged from a point near the lens. This point is the *principal focus.* (Fig. 13.)

Conjugate Foci of Concave Lenses are also virtual, and found in a similar manner.

Formation of Images by a Lens: Optical Centre.—In the lens (Fig. 14) the point *O* on the axis is called the *optical centre.*

Fig. 14.



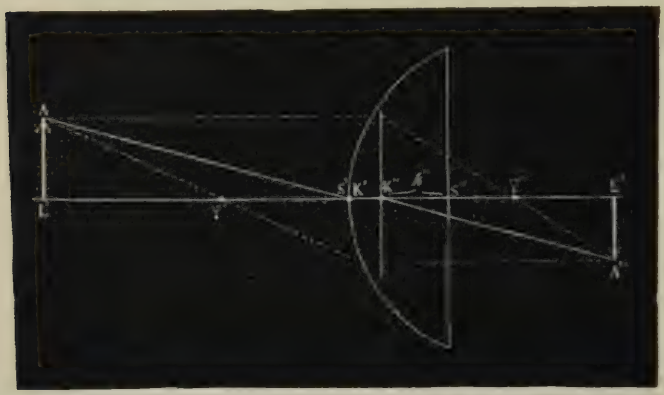
O. Optical centre of lens (Landolt). The point C'' is the centre of curvature for the surface S''. The point C' is the centre of curvature for the surface S'. A ray passing from C'' to C' would be perpendicular to both surfaces. It would pass through without deviation. This ray is called the *axial ray*, or *axis.*

The radii $C''J''$, and $C'J'$, being parallel, a ray in the lens passing in the direction $J'J''$ must form equal angles at the two surfaces. The point where this ray intersects the axis is the *optical centre.*

Any ray passing through this point is refracted equally at both surfaces, since it forms equal angles with the radii of the two surfaces. The direction of the ray is therefore the same after refraction by the second surface as it was before refraction by the first. For thin lenses it may be said that any ray directed to the optical centre passes through without deviation. These rays are called *secondary axes.*

The ray drawn from any point in an object to the optical centre of a lens gives the line on which the image of the point is to be found. A ray from the same point in the object, passing in a direction parallel to the axis, would be refracted to the principal focus of the lens, since the principal focus is the focus for parallel rays. (Fig. 15.)

Fig. 15.



Position and size of image formed by convex lens (Landolt).—The ray *A*, *K'*, from the point *A*, being directed to the optical centre of the lens, continues its course in a parallel direction *K'' A''*. Another ray passing from *A*, parallel to the axis *L' L''*, is refracted through ϕ'', the principal focus, and, intersecting the ray *A K'' A''*, determines the position of the image of the point *A*. Still another ray passing from *A* through the anterior principal focus ϕ', after refraction, is parallel with the axis *L' L''*, and meets the other rays in the point *A''*.

In order to find the position and size of an image formed by a lens, it is only necessary to draw two lines from each extremity of the object: one passes through the optical centre of the lens; and the other, parallel with the axis of the lens, would be refracted to the principal focus. The *position of the image* is found at the points where these lines intersect.

The size of the image is proportional to the size of the object, as the distance of the image from the optical centre is to the distance of the object from the optical centre. When the object is situated at a greater distance from the lens than its principal focus, the image is a real, inverted one.

In the figure (Fig. 16), *O B* is the object; the rays diverging

from O intersect in O', which is the position of the image of the point O. Similarly the rays from B unite in B', the position of the image of the point B; B' O' is the image of $O\,B$.

Fig. 16.

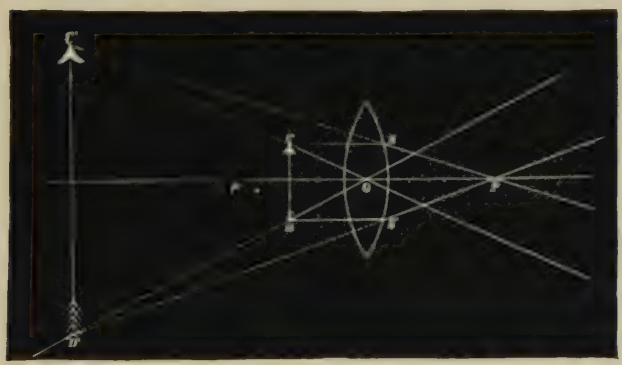


Image formed by a convex lens. O B is the object; O' B' is the inverted image.

When the object is situated nearer to the lens than its principal focus, the image is a virtual, erect one.

The *virtual* image of a *convex* lens appears to be at the point from which the rays refracted by the lens seem to have diverged.

Fig. 17.



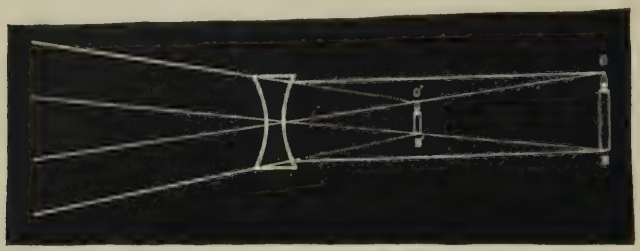
Virtual image of a convex lens. C D is the object; C' D' is the virtual image, erect and magnified.

(Fig. 17.) From the point C, of the object $C\,D$, the ray $C\,S$ is parallel to the axis. It therefore is refracted to the principal focus, P. The ray $C\,O$ passes through unchanged. By projecting these rays backwards they meet in C', the image of the point

C. The rays from the point *D* seem to have diverged from *D'*. An enlarged, *erect* image is thus formed in *C' D'*.

The image formed by a *concave* lens is always *virtual* and diminished. Two rays proceeding from a point *O*, in the object, one

Fig. 18.



Virtual image of a concave lens. *O' B'* is the virtual image of the candle, *O B*, erect and diminished in size.

parallel to the axis, which seems after refraction to have diverged from the principal focus, and is traced backwards, and the other, which is directed to the optical centre, at their intersection, denote the position of this point in the image. (Fig. 18.)

Focal Distance of a Lens.—The distance from the optical centre of a lens to the focal point is called the *focal distance.*

The length of this depends upon the radii of curvature of the surfaces of the lens, and on its index of refraction. Representing the radius by r, the index of refraction of the lens by n, that of air being 1, $F = \frac{r}{2(n-1)}$, is the formula for obtaining the focus of a bispherical convex or concave lens. The formula for a plano-spherical lens is $F = \frac{r}{n-1}$, as the refraction is effected at one surface. The mode of obtaining this is given below.[1] (Fig. 19.)

[1] I. In the plano-convex lens *L*, the surface *D* being perpendicular to the incident ray, no refraction takes place. *S* is the convex surface, *C I* is the radius of curvature, *r*. *R I* is the incident ray, *I F* is the refracted ray, *R I C* is the angle of incidence, *H I F* is the angle of refraction, equal to *H I P* + *P I F*. *H I P* = *R I C*.

P I F, the ang. of deviation, = *H I F* — *H I P*.

Angle of deviation = ang. of refraction — ang. of incid.

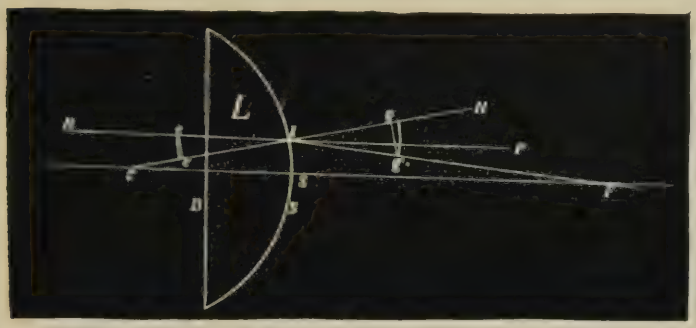
II. If *e e'* = sine of the ang. of incidence, then *g g'* = sine of the ang. of

Numeration of Lenses.—The refractive power of a lens is the inverse of its focal distance. If the refractive power of a

refraction (the radii $I\,e$ and $I\,g'$ being equal). $e\,e'$ is inversely proportional to $g\,g'$, as the index of refraction of the lens is to that of air. (See page 19.)

Representing the index of the lens as n, that of air being 1, we have $e\,e' : g\,g' :: 1 : n$.

Fig. 19.



The angles $R\,I\,C$ and $H\,I\,F$, being small, are proportional to their sines.

$R\,I\,C : H\,I\,F :: e\,e' : g\,g'$; or, substituting, $R\,I\,C : H\,I\,F :: 1 : n$.

$n\,(R\,I\,C) = H\,I\,F$.

If $R\,I\,C = 1$, $H\,I\,F = n$.

III. Ang. of refraction $= n$.

Ang. of incid. $= 1$.

Ang. of deviation = ang. of refrac. — ang. of incid. $= n - 1$.

In the two triangles, $S\,C\,I$ and $S\,F\,I$, the angle $I\,C\,S = R\,I\,C$, ang. of incid. The angle $I\,F\,S = P\,I\,F$, angle of deviation. The side $I\,S$ being common, the angles are inversely proportional to the bases of their respective triangles.

$I\,C\,S : I\,F\,S :: F\,S : C\,S$. $F\,S$ nearly equals $F\,I$.

$I\,C\,S$ = ang. of incid. $= 1$. (II.)

$I\,F\,S$ = ang. of deviation $= n - 1$. (III.)

$F\,S$ = focus F. $C\,S$ = radius r.

$1 : n - 1 :: F : r$.

$$F = \frac{r}{n - 1}.$$

The focus of a plano-spherical lens is equal to the radius of curvature, divided by the index of refraction — 1.

In a bi-spherical lens the ray is refracted at each surface; if the radii of curvature are equal, the refraction is the same at each surface, or double that of a plano-spherical lens. The focus will consequently be one-half that of a plano-spherical lens. $F = \frac{r}{2(n-1)}$.

lens whose focal distance is one metre is represented by 1, then a lens whose focal distance is two metres has only one-half the refractive power of the first, since the rays are not bent so sharply by the second lens. Again, if a lens bends rays so sharply that they meet the axis at one-half metre's distance, its refractive power is twice that of a lens of one metre focus.

The focus of a bi-convex lens (with equal radii), made of glass with an index of 1.50, has the same length as the radius of curvature.

$$F = \frac{r}{2(n-1)} = \frac{r}{2(1.50-1)}$$
$$F = r.$$

Glass used in spectacle lenses has an index of 1.53, consequently—

$$F = \frac{r}{1.06}$$
$$r = 1.06\ F.$$

In the old system the lenses were marked according to their radii of curvature in Paris inches, and the focal distance was somewhat less than the radius of curvature. As all the lenses in use had longer focal distances than 1 inch, they were fractions of the refractive power of a lens of 1 inch focus, viz., $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, etc.

In 1867 Nagel proposed to number lenses by their refractive power. By adopting as a standard a lens of longer focal distance than one inch, viz., one metre (40 inches), the greater number of lenses are made multiples of refractive power of the standard, and are based on their focal lengths in metres and fractions of a metre, instead of being based on their radii of curvature.

The term *dioptre* was proposed by Monoyer for a lens of 1 metre focus. A lens of 2 metres focus is only $\frac{1}{2}$ the refractive power, or 0.50 D. The present scale of lenses comprises a series from 0.12 D to 22 D. Between 0.12 D and 1.25 D the lenses have an interval of 0.12 D. From 1.25 D to 5 D the interval is 0.25 D, from 5 to 8 D an interval of 0.50 D, from 8 to 18 D an interval of 1 D, and from 18 to 22 D the interval is 2 D. This uniformity in the intervals between the lenses is an important

advantage over the old system, in which the lack of uniformity in this respect was a conspicuous feature.

To find the focal length of any lens in the dioptric system divide one metre, or 100 centimetres, by the number of dioptres: thus, the focal length of a lens of 5 D is $\frac{100}{5} = 20$ cm.

	No. of lens in dioptres.	Focal distance in millimetres.	Focal distance in English inches.	Nearest corresponding lens in old system.
Interval of 0.12 D.	0.12	8000	314.96	
	0.25	4000	157.48	144
	0.37	2666	104.99	
	0.50	2000	78.74	72
	0.62	1600	62.99	60
	0.75	1333	52.5	48
	0.87	1143	44.99	42
	1	1000	39.37	36
	1.12	888	34.99	
	1.25	800	31.5	30
Interval of 0.25 D.	1.50	666	26.22	24
	1.75	571	22.48	
	2	500	19.69	20
	2.25	444	17.48	18
	2.50	400	15.75	16
	2.75	363	14.31	15 or 14
	3	333	13.12	13
	3.25	308	12.11	12
	3.50	285	11.25	11
	3.75	267	10.49	10
	4	250	9.84	9
	4.25	235	9.26	
	4.50	222	8.74	8
	4.75	210	8.29	
	5	200	7.87	
Interval of 0.50 D.	5.50	182	7.16	7
	6	166	6.54	
	6.50	154	6.06	6
	7	143	5.63	5
	7.50	133	5.25	
	8	125	4.92	
Interval of 1 D.	9	111	4.37	4.5
	10	100	3.94	4
	11	91	3.58	3.5
	12	83	3.27	3.25
	13	77	3.03	3.
	14	71	2.8	2.75
	15	66	2.64	
	16	62	2.44	2.5
	17	59	2.32	2.25
	18	55	2.17	
Interval of 2 D.	20	50	1.97	2.
	22	45	1.79	

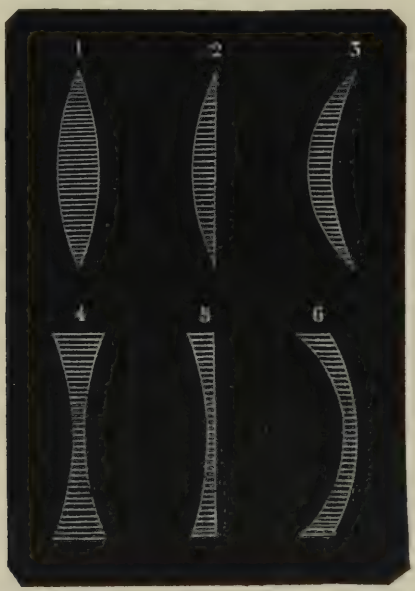
In the old system, the lenses are ground with a radius of curvature in Paris inches. The focal length is almost exactly the same in English inches as the radius of curvature is in French inches. The English inch = 25.4 mm.; the French inch = 27.07 mm.; 25.4 × 1.06 = 26.92.

In column 3 of the table, the focus is given in English inches, as it is customary to compare the French lenses with the dioptres by their focal length in English inches. A lens of 1 dioptre has a focal length of 39.37 English inches. There is no lens in the old system which corresponds to it exactly. The nearest equivalent would be a lens of 40 inches.

The lenses used for spectacles are spherical and cylindrical.

Spherical Lenses.—A spherical lens is represented by a section of a sphere, or of two sections of a sphere placed together by

Fig. 20.



1. Biconvex lens. 2. Plano-convex lens. 3. Concavo-convex lens, convergent meniscus. 4. Biconcave lens. 5. Plano-concave lens. 6. Convexo-concave lens, divergent meniscus.

their plane surfaces. Light passing through a spherical lens is refracted equally in all planes.

Cylindrical Lenses.—A cylindrical lens is a section of a cylinder parallel to its axis. Light passing through a cylindrical lens in a plane parallel to its axis is not refracted. At right angles to the axis, parallel rays are rendered convergent or divergent, according as the cylinder is convex or concave.

Convex lenses are designated + ; concave lenses —.

Combination of Lenses.—If two or more lenses are placed together, say + 2 dioptres + 3 dioptres and + 4 dioptres, the combination forms a dioptric power equal to their sum, viz., 9 dioptres; such a combination has, with thin lenses, a focal distance of $\frac{100}{9} = 11$ centimetres. If these lenses are placed at their focal distance from an object, the rays coming from the object, after passing through the lenses, are parallel.

Two or more concave lenses placed together likewise produce a dioptric effect equal to their sum.

Combination of Convex and Concave Lenses.—If a concave lens and convex lens of equal strength be placed together, they will neutralize each other so exactly that a distant object viewed through them will appear neither enlarged nor diminished, and there will be no prismatic deviation on gently shaking the lenses in a direction parallel to the surface.

Should they be unequal, on shaking them, an object (the edge of a wall or window frame is suitable) will be displaced towards the centre of the lens, if the concave is stronger, and away from the centre, if the convex is stronger. The value of the combination will be the difference between the strength of the two. For instance, a + 3 dioptre and a — 2 dioptre equal + 1 dioptre; a + 2 dioptre and — 4 dioptre = — 2 dioptre.

A — 2 dioptre lens gives to parallel rays a direction as if they came from a point 50 centimetres away. Conversely, we may represent rays diverging from any near point by the concave lens whose principal focus equals that distance. Let rays, for example, diverge from a point 15 centimetres away; they evidently are similar to parallel rays which have passed through a concave lens of 15 centimetres focal distance, $\frac{100}{15} = 6.66$ dioptres.

If we wish to find the conjugate focal distance of any lens for rays which diverge from 15 cm., we subtract 6.66 from the dioptric power of the lens; the remainder gives a lens whose focal

distance would be the conjugate desired. If we wish to find the conjugate focal distance of a 12 dioptre lens for rays which diverge from 15 cm., we subtract 6.66 from 12 = 5.33 dioptres; 18.8 cm. is the conjugate focal distance.

Combination of Cylindrical Lenses with Spherical Lenses.—A cylindrical lens is curved only in the direction *perpendicular to its axis;* rays which enter the lens in this plane are refracted to the focus of the lens exactly as in the case of a spherical lens.

In the opposite direction, that is *parallel to its axis,* the surface of a cylindrical lens is flat; rays entering in this plane are not refracted, but pass through unchanged. The effect of a cylindrical lens placed in front of the eye is to increase or diminish its refraction in the direction at right angles to its axis, but in the opposite direction the refractive power is unchanged.

A convex 4-dioptre cylindrical lens, with its axis in a vertical direction (written + 4 D cyl., axis 90°), increases the refraction in the horizontal direction 4 dioptres, but does not alter the refraction in the vertical direction. The horizontal plane is expressed by the term *horizontal meridian;* the vertical plane by the term *vertical meridian.*

A concave cylindrical lens of 4 dioptres, with its axis horizontal, (written —4 D cyl., axis 180°) diminishes the refraction of the vertical meridian 4 dioptres, but does not affect the refraction of the horizontal meridian.

A convex lens of 3 dioptres, combined with a convex cylindrical lens of 2 dioptres, with its axis vertical (written + 3 D ⌒ + 2 D cyl., axis 90°), adds to the horizontal meridian + 5 dioptres, but to the vertical meridian only 3 dioptres.

The combination of a convex spherical lens with a concave cylindrical lens has the following effect: In the direction parallel to the axis of the cylinder the combination equals the full refraction of the spherical; in the direction at right angles to the axis of the cylinder the refraction is equal to the difference between the two lenses. If the convex spherical is stronger than the concave cylinder, the difference is still represented by a convex glass. For example, + 2 D sph., ⌒ — 1.50 D cyl., axis 180° = + 0.50 D sph., ⌒ + 1.50 D cyl., axis 90°, because + 2 D in the meridian of 180° is not diminished, but in the meridian of 90° it is

reduced to + 0.50 D. Now, + 0.50 D sph. produces this amount of refraction at 90°, and supplies + 0.50 D of the requisite + 2 D at 180°, leaving + 1.50 D to be supplemented by a cylindrical lens with its axis at 90°.

In place of writing + 2 D sph., ⌒ — 1.50 D cyl., axis 180°, a more simple expression would be + 0.50 D sph., ⌒ + 1.50 D cyl., axis 90°.

When, however, the concave cylindrical lens is stronger than the convex spherical the difference is represented by a concave lens, thus + 3 D sph., ⌒ — 6.50 D cyl., axis 180°, signifies in the horizontal meridian convex 3 D, and in the vertical meridian concave 3.50 D. It is necessary to combine a convex with a concave lens in order to obtain this effect. The refractive power of this combination can be expressed in three different ways :—

+ 3 D sph., ⌒ — 6.50 D cyl., axis 180°.
— 3.50 D sph., ⌒ + 6.50 D cyl., axis 90°.
+ 3 D cyl., axis 90° ⌒ — 3.50 D cyl., axis 180°.

In the first combination + 3 D sph. gives the + 3 D necessary for the horizontal meridian, but increases the refraction of the vertical meridian 3 D instead of diminishing it ; therefore the — 6.50 D cyl., axis 180°, expends 3 D of its refractive power in neutralizing the effect of the + 3 D sph., and with the remainder diminishes the refraction of the vertical meridian 3.50 D.

In the second combination, — 3.50 D sph., ⌒ + 6.50 D cyl., axis 90°, the concave spherical lens diminishes the refraction of the vertical meridian 3.50 D, but also diminishes the refraction of the horizontal meridian 3.50 D ; as this already requires + 3 D, we must add + 3.50 D more to compensate for the concave spherical, making + 6.50 cyl., axis 90°.

In the third combination, + 3 D cyl., axis 90° ⌒ — 3.50 D cyl., axis 180°, + 3 D cyl., axis 90°, increases the refraction of the horizontal meridian without altering the refraction of the vertical meridian, and the — 3.50 D cyl., axis 180°, diminishes the refraction of the vertical meridian without affecting the refraction of the horizontal.

With the combination of a convex spherical and cylindrical lens, *e. g.*, + 3 D sph., ⌒ + 2 D cyl., axis 90°, a concave 0.50 D cylinder with its axis at right angles to the axis of the convex

cylinder, in this case at 180°, diminishes the refraction of the vertical meridian 0.50 D, the combination then equals + 2.50 D in the vertical meridian and + 5 D in the horizontal = + 2.50 D sph., ⌒ + 2.50 D cyl., axis 90°.

A convex cylinder + 0.50 D added to the same combination, with its axis at right angles to the axis of the first cylinder, that is, + 0.50 D cyl., axis 180° with + 3 D sph., ⌒ + 2 D cyl., axis 90°, increases the refraction in the vertical meridian + 0.50 D. The combination then equals + 3.50 D in the vertical meridian, + 5 D in the horizontal. This is obtained by + 3.50 D sph., ⌒ + 1.50 D cyl., axis 90°.

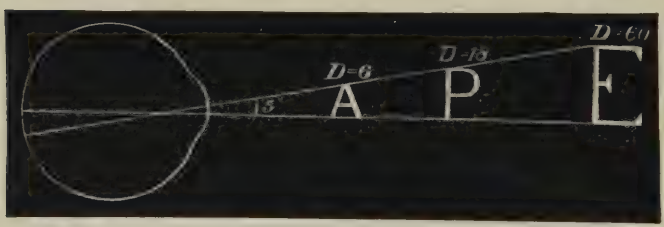
Visual Angle.—The apparent size of an object depends upon the size of the *visual angle.*

The visual angle is the angle formed by the lines drawn from the two extremities of an object to the nodal point of the eye. The nodal point of the eye is analogous to the optical centre of a lens. It is situated 15 mm. in front of the retina, and 7 mm. behind the cornea. Rays directed to this point pass through without deviation.

As the rays directed to the nodal point of the eye are not refracted, but continue the same course until they strike the retina, if lines are drawn from the extremities of an object through the nodal point of the eye, and continued until they fall upon the retina, the size of the retinal image of the object is obtained.

The figure shows that the object, in order to subtend the same

Fig. 21.



The Visual Angle.

angle, must be larger the farther it is removed from the eye. The letter *A*, seen clearly at 6 metres, would have to be three times as large in order to be seen distinctly at 18 metres, and

ten times as large in order to be seen clearly at 60 metres. The visual angle in the three cases remains the same.

Visual Angle in Emmetropia.—In the emmetropic eye the *nodal point* is situated 7 mm. behind the cornea, and 15 mm. in front of the retina. The size of the retinal image is, to the size of the object, as the distance from the retina to the nodal point (15 mm.) is to the distance from the nodal point to the object. Therefore, if an object is situated at 1 metre distance (1000 mm.), its image will be $\frac{15}{1000}$ of the size of the object.

Retinal Image in Ametropia.—In hypermetropia, the axis of the eye being shorter, the retina is situated nearer the nodal point; the image is therefore smaller: while in myopia, with an increase in the axis of the eye, the retinal image is larger.

Visual Acuteness; Limit of Perception.—An object one centimetre in size placed one metre distant from an emmetropic eye (that is, an eye without any error of refraction), which is normal in other respects, is plainly visible. If this object is moved farther and farther away, it forms a progressively smaller visual angle, until a point is reached beyond which it cannot be perceived, owing to the diminutive size of the visual angle. The *limit of perception* has now been reached.

The angle which the object subtends, at this distance from the eye, represents the maximum *acuteness of vision*. An object twice the size would be seen distinctly at twice this distance. An object one-half the size could not be distinctly seen at more than half this distance. Therefore, the size of the object denoting the acuteness of vision is always proportional to the distance.

Normal Acuteness of Vision.—Snellen determined the normal acuteness of vision to be the power of distinguishing letters subtending an angle of 5′. These letters were formed of strokes whose width was $\frac{1}{5}$ the size of each letter; consequently, they were seen under an angle of only 1′. The openings in the letters and the spaces between contiguous strokes, as nearly as possible, were made to conform to the same angle.

The relation of the size of the letter to the distance at which it should be discerned by a normal eye is expressed by the tangent of the angle of 5′ = .001454. The size of a letter, the perception of which constitutes normal vision at a given distance, may

be obtained by multiplying the distance by .001454. At the distance of one metre the size of this standard letter is 1.45 mm. (.001454 × 1000 mm.). At a distance of six metres the size of the letter required is 8.7 mm. (1.45 × 6). The size of the retinal image of a standard letter of six metres = $\frac{1}{6}\frac{5}{0}\frac{5}{0}$ of 8.7 = .02175 mm., and the strokes, or openings, being $\frac{1}{5}$ the size, have an image of .00435 mm. A large number of people, after correction of their ametropia, have a visual acuity of 1.25 of normal, and therefore letters, constructed on an angle of 4′, have been used for testing visual acuity. The retinal images of the strokes of such letters are $\frac{4}{5}$ of .00435 = .00349 mm. The size of the cones of the macular region varies from .0033 mm. to .0036 mm., showing a most interesting relation between the limit of perception and the anatomical structure of the retina.

ACCOMMODATION.

In all lenses the focal distance becomes longer as the object is brought closer. The eyeball being inextensible, the adaptation for different distances is not effected by increasing the length of its axis, but by increasing the refractive power of the lens.. The rays diverging from near objects are thus brought to a focus at the same distance as the rays diverging from remote objects. The power the eye possesses of adapting its refraction for different distances is called *accommodation.*

This function of the eye is effected by the ciliary muscle in the following manner: The crystalline lens is a soft body inclosed in a capsule and attached by its suspensory ligament to the ciliary processes. The ciliary body having a fixed point at the corneo-scleral junction, when its muscular fibres contract, the attachments of the suspensory ligament are brought closer together, the capsule becomes relaxed, and the soft lens bulges forward and becomes more convex. It has now added to its anterior surface another convex lens. As the ciliary muscle contracts more vigorously the additional convex lens becomes stronger.

If an emmetropic individual wishes to see an object situated 25 cm. distant, he must add to his crystalline lens another lens of 4 dioptres, *i. e.*, one having a focal length of 25 cm. The effect

of this extra lens is to give to rays diverging from 25 cm. a parallel direction. They will then be brought to a focus on the retina.

Fig. 22.



Increased convexity of the lens during accommodation. The solid white outline of the lens, *l*, shows its form when relaxed. The dotted line shows the increased curvature of the anterior surface during accommodation, and its advancement forwards into the anterior chamber, *a*. *Z* is the suspensory ligament; *m*, the ciliary muscle; and *i*, the iris.

In the same manner, if the point is at 10 cm., an additional lens of 10 cm. focus is required, so that these divergent rays may be rendered parallel.

For every distance of the object the degree of accommodation varies. It is not possible for the eye to be adapted for two different distances at once. If one stands in front of a window pane, on which a spot is placed, and tries to see distinctly the spot and objects on the other side of the street, he will find that, when the spot is distinct, objects across the way are blurred, and *vice versa*. By means of the accommodation the eye is adjusted for all distances between its farthest and nearest point of distinct vision.

The **far point** of an eye, *punctum remotum*, or *r*, is the greatest distance at which the eye still has maximum visual acuity. When the eye is accommodated for its far point, the ciliary muscle is

entirely relaxed, and the eye is in the condition of minimum refraction. This is expressed by R.

The **near point** of an eye, *punctum proximum*, or p, is the nearest point at which the eye still has maximum visual acuity; the ciliary muscle is now contracted to its fullest extent, and the eye is in its condition of maximum refraction. This is expressed by P.

The **range of accommodation**, likewise denominated the *power* or *amplitude of accommodation*, is the difference between the refractive power of the eye accommodated for its far point and accommodated for its near point. This is expressed by A. $A = P - R$.

As the refractive power is the inverse of the focal distance, the refractive power of the eye, when accommodated for its far point r, is $R = \frac{1}{r}$. If we express the value of r in metres, we shall then have the refractive power of the eye expressed in dioptres, a dioptre being a lens of 1 metre focus. If $r = 1$ metre, $R = \frac{1}{1} =$ 1 dioptre = 1 D. If r is infinitely distant, $R = \frac{1}{\infty} = 0$.

In the same manner $\frac{1}{p} = P$, the refractive power of the eye when accommodated for its nearest point. If we obtain the value of p in centimetres, and wish to know how many dioptres it equals, we must divide 100 by the number of centimetres equal to p. Let $p = 10$ cm., then $P = \frac{100}{10} = 10$ D. If p is expressed in fractions of a metre, we obtain the same result: by dividing 1 by the value of p, in metres, 10 cm. $= \frac{1}{10}$ of a m. $P = \frac{1}{\frac{1}{10}} = 10$ D., or, in decimals, $1 \div .1$ m. $= 10$ D., that is, in order to focus rays from 10 cm., we require 10 times as much accommodation as is necessary to focus rays from 1 metre, and since an eye adapted to a distance of 1 metre exerts 1 dioptre of accommodation, at a distance of $\frac{1}{10}$ m., or 10 centimetres, it must therefore exert 10 dioptres of accommodation.

To find the range of accommodation, we must first determine

the far point. This is accomplished by means of test letters held in front of the patient. If the patient has maximum acuity of vision at 6 metres, his *far point* is infinite; R then $= \frac{1.}{\infty} = 0$. If vision is less than normal at 6 metres, but is normal at 1.5 metres, $r = 1.5$ metres; R then $= \frac{1}{1.5} = .66$ D. If vision is not distinct at any distance but when a convex glass of 2 D. is placed before the eye, it becomes normal at 6 metres, then $R = -2$ D.; that is, the far point of such an eye is behind the retina, and is *negative;* this will be further described in its proper place. (See page 143.)

The *near point* is found by holding in front of the patient finely-printed reading matter, and measuring the nearest distance to his eye at which this is distinct. For this purpose large print may be reduced by photo-lithographing, so as to correspond at 25 cm., and less, with the 5′ angle standard.

The *formula for obtaining the range of accommodation* is $A = P - R$. If p is at 20 cm., $P = \frac{100}{20} = 5$ D., and r is at infinity, $R = 0$, then $A = P = 5$ D. This is the case in emmetropia.

If p is at 10 cm., $P = \frac{100}{10} = 10$ D., and r is at 25 cm., $R = \frac{100}{25} = 4$ D., then $A = 10$ D $- 4$ D $= 6$ D. This is the case in myopia of 4 D. P is greater than A.

If p is at 50 cm., $P = \frac{100}{50} = 2$ D., and r is negative, -25 cm. $R = \frac{100}{-25} = -4$ D. $A = 2 - (-4) = 2 + 4 = 6$ D. This is the range of accommodation in a hypermetrope of 4 D., and equals the sum of P and R.[1]

The near point is closer to the eye in young life while the lens is soft; as age advances the lens becomes harder and the near point gradually recedes until, when the age of 73 is reached, the

[1] p refers to the distance of the near point in centimetres. P refers to the refractive power of the eye in accommodation for p. r refers to the distance of the far point. R refers to the refraction of the eye when accommodated for r.

near point has reached infinity, and p and r then coincide, and there is no range of accommodation.

The failure of the accommodation due to age is termed *presbyopia.* This is more fully described under Presbyopia (see page 175).

The *range of accommodation* is nearly constant for the same age, so that if p is nearer than it should be myopia may be

Fig. 23.

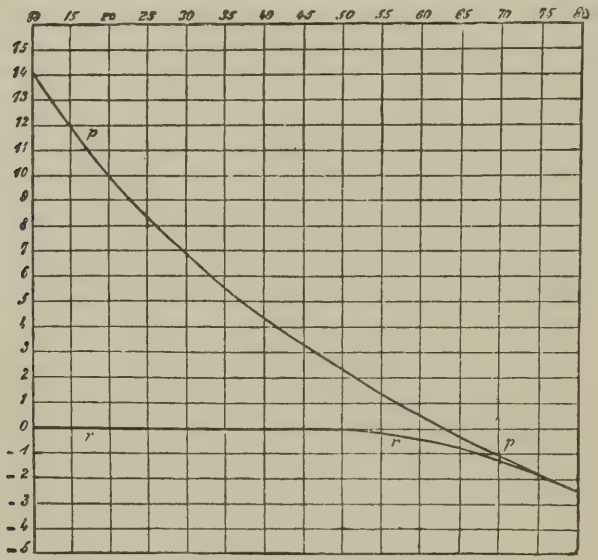


Diagram of the range of accommodation (Landolt). The vertical column of figures on the left hand side indicates the dioptres of accommodation. The horizontal line of figures at the top represents the ages. The curved line, $p\ p$, represents the refractive power of the eye at different ages, when accommodated for its near point. The line $r\ r$ represents the refraction of the eye when relaxed for its far point. At 55 years it is supposed to become hypermetropic; r then becomes negative.

suspected, or if it is farther away than the average, hypermetropia. (Fig. 23.) For this purpose the table given below is used, which records the average of p in dioptres for the different ages.

Table of the range of accommodation.

10 years	14 dioptres	$p =$	7 cm.
15 "	12 "	" =	8.3 "
20 "	10 "	" =	10 "
25 "	8.5 "	" =	12 "
30 "	7 "	" =	14 "
35 "	5.5 "	" =	18 "
40 "	4.5 "	" =	22 "
45 "	3.5 "	" =	28 "
50 "	2.5 "	" =	40 "
55 "	1.75 "	" =	55 "
60 "	1 "	" =	100 "
65 "	.75 "	" =	133 "
70 "	.25 "	" =	400 "
75 "	0 "	" =	∞

The ciliary muscle is most fully developed in hypermetropic eyes; the circular fibres are here very numerous. In myopic eyes they are less numerous and sometimes wanting. As a result of this, the accommodation is greater in hypermetropia, and more feeble in myopia.

This point is of importance in connection with the prescribing of glasses. It sometimes is impossible to make the hypermetrope relax his accommodation entirely, even for distance, and the myope is often distressed if he is forced to accommodate by concave glasses. In young persons the accommodation renders hypermetropia latent, and the eye may appear emmetropic or even myopic; it also causes emmetropia to simulate myopia, and myopia to appear higher than it actually is.

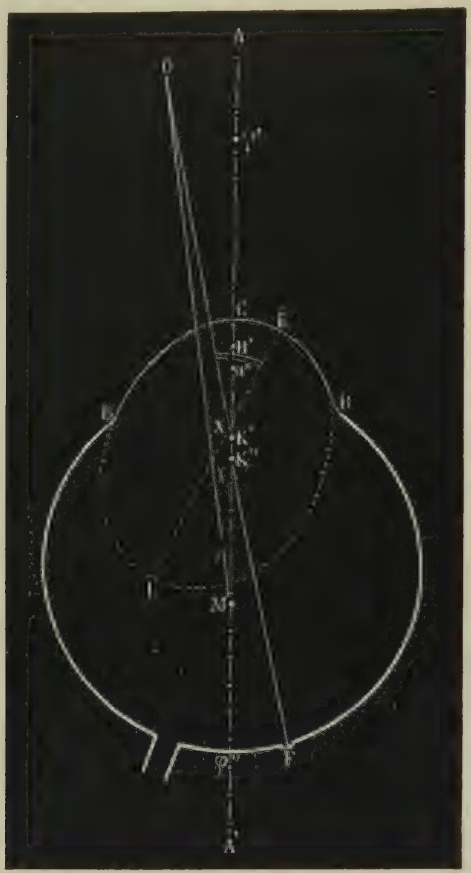
Angle Gamma: Angle Alpha.—The eye in looking at any object is directed forwards in such a manner that the image is formed on the *macula lutea*. The eye is now said to "fix" the object. A line, drawn from the object thus fixed, to the macula lutea, is called the *visual line*, or *visual axis*.

The point about which the eye revolves, in order to be brought into this position, is called the *centre of rotation*, and has its position 14 mm. back of the cornea. The line which connects the object with the centre of rotation is designated the *line of fixation*.

The *optic axis* is an imaginary line, passing through the centre of the cornea and lens and the point of rotation, to the posterior pole of the eye, *i. e.*, a point usually between the macula and optic papilla.

If the macula lutea coincided with the posterior extremity of the optic axis, the visual line, line of fixation, and optic axis

Fig 24.



Angle alpha and angle gamma. (Landolt.) *A A'*, optic axis; *O F*, visual line; *O M*, line of fixation; *E L*, major axis of corneal ellipse. The line of fixation does not correspond with the optic axis, but forms the angle *O M A*, angle gamma nearly equal to the angle *O X A*, formed by the visual line with the optic axis. *O X A* may be considered as the angle gamma. The visual line does not pass through the summit of the corneal curve, *E*, but forms with the axis of the cornea, *E L*, the angle *O X E*, the angle alpha.

would also coincide. Generally, this coincidence does not exist. In emmetropia and hypermetropia the optic axis passes to the

inner side of the macula lutea, and the visual line and line of fixation then form angles with the optic axis. In Fig. 23 *A A'* is the optic axis passing through the centre of the cornea, *C* the nodal points of the eye, *K' K''*, and the centre of rotation, *M*. *O F* is the visual line connecting the object, *O*, with the *fovea*, *F*. *O M* is the line of fixation, drawn from *O* to the centre of rotation, *M*. The eye, in order to fix *O*, has its optic axis, *A A*,' deviated outwards. The angle formed by the line of fixation, *O M*, with the optic axis *A A'*, is called the *angle gamma*, γ, or, the angle formed by the visual line with the optic axis may be considered as the angle gamma.

The significance of this angle is, that a person while really fixing an object seems to have a divergence of the visual lines —divergent squint. In estimating the degree of a divergent strabismus it is necessary to consider the value of this angle. The amount of the angle gamma is usually 5°, but it may reach as much as 10°. When the anterior extremity of the visual line passes to the inner side of the optic axis, the angle gamma is positive, or + ; this is the usual condition in emmetropia and hypermetropia. The convergence of the visual line exceeds the convergence of the optic axis by the amount of this angle. When the visual line coincides with the optic axis there is no angle gamma. The visual line in high myopia sometimes passes to the outer side of the optic axis. The eyeball must then be deviated inwards in order to fix on the object. This produces the effect of a convergent squint. It must be distinguished from squint ; and if convergent strabismus also exists, the value of this angle must be deducted from the apparent squint. In this latter form of the angle gamma, where the anterior extremity of the visual line passes to the outside of the optic axis, the angle gamma is negative, or —. The convergence of the visual line is less than the convergence of the optic axis by the amount of this angle.

The amount of this angle may be measured by placing the patient before the perimeter as if his field were to be taken. The eye is fixed on the central point, and a lighted candle is moved along the arc in a horizontal direction until its reflection is obtained from the portion of the cornea corresponding to the centre

of the pupil. The position of the candle may now be read from the arc in degrees, and represents the size of the angle gamma.

The apex of the cornea does not generally coincide with the centre of the cornea, but is displaced laterally. The major axis of the corneal ellipse, represented in the figure by *E L*, therefore forms an angle with the visual line. The *angle alpha* is the angle formed by the visual line with the major axis of the corneal ellipse. It is *positive* when the major axis of the cornea passes to the outer side of the visual line; if the corneal axis passes to the inner side of the visual line, the angle alpha is *negative*. In the figure the angle *O X A* is the *angle gamma;* the angle *O X E* is the *angle alpha*.

From what has been said it will be seen that the visual line is a secondary axis to the optical system of the eye. The oblique position of the refracting surfaces to the visual line may be the cause of an increased refraction in the horizontal meridian constituting astigmatism.

CONVERGENCE.

In the visual act of one eye the sensation conveyed to the brain is projected outwards over the same course by which it arrived, that is, the object is referred to a position in the field of vision which it actually occupies. If the projection outwards of the images of the two eyes is such that they overlie each other, the person will have single vision; if, however, they are projected in different positions, double vision is the result.

The images are projected in different positions when they are not formed on *identical points* of the two retinas. The *fovea centralis* being the most sensitive portion of the retina, the eye is naturally so directed towards an object that the image is formed upon it. The eye is then said to fix the object. The foveæ of the two eyes are identical points, and images formed on them are projected outwards so as to overlie, or fuse into each other; points at a corresponding distance to the right of each fovea, or to the left, or upwards or downwards, are also identical, and images formed on them produce but a single impression. Objects in the field of vision to the right of the point of fixation form a retinal image to the left of the fovea. Objects to the left

of the point of fixation form an image to the right of the fovea. (See Figs. 15 and 21.) All images formed on the retina to the right of the fovea are projected outwards to the left. Those formed on the left of the fovea are projected to the right; in the same way those formed on the upper part of the retina are projected downwards, those formed on the lower part of the retina are projected upwards.

The eyeballs are separated laterally, on the average, 64 mm. in adult eyes. In looking at a distant object, if the axes of the eyes are parallel, the images are formed on corresponding points of the retinas, but when the object is at some nearer point the eyes must be turned inwards in fixing the object, to compensate for their lateral separation. This function of the eyes is termed *convergence.*

The eyeball is rotated inwards by the internal rectus muscle, so that its visual line is directed towards the object. This function is very closely associated with that of *accommodation;* one cannot act in any considerable degree without the other also coming into play. The movement inwards of the eye is measured by the angular deviation of the visual line, termed the *angle of convergence.*

The unit of convergence is the angle through which the visual axis moves to fix on a point 1 metre distant. This is termed one-metre angle of convergence (Nagel). (Fig. 25.) If the object fixed is only $\frac{1}{2}$ metre distant, the movement will be twice as great; it is then 2-metre angles. A point $\frac{1}{3}$ of a metre would require 3-metre angles,

Fig. 25.



Metre angles of convergence (Landolt.)

and so on. 10-metre angles of convergence mean that the eye is directed to a point only $\frac{1}{10}$ of a metre distant.

Metre Angle.—In the figure, O and O' represent the centres of rotation of the two eyes; $O\,O'$ is the distance between these points, termed the interocular distance. It is measured by the distance between the pupils during fixation for remote objects. $O\,M$ is one-half this distance.

The line $C\,M$ is perpendicular to $O\,O'$. When the object is situated on the line $C\,M$ the convergence of each eye is equal. When the visual lines $J\,O$ and $J'\,O'$ are parallel, the angle of convergence is *nil;* when, however, the visual lines are directed to C', one metre distant, $O\,J$ has deviated to $O\,C'$. $J\,O\,C'$ is the angle through which the visual line has moved to fix on C'. This is one-metre angle of convergence.

$C\,M$ being parallel to $J\,O$, $O\,C'\,M$ is equal to $J\,O\,C'$.

In the right-angled triangle $O\,C'\,M$, $O\,M$ equals $\frac{1}{2}$ the interocular distance.

$O\,C'$ = the distance of the point of fixation.

$\frac{O\,M}{O\,C'}$ = the sine of the angle $O\,C'\,M$.

The average interocular distance is 64 mm. $O\,M = \frac{1}{2}$ of 64, or 32 mm. $O\,C'$ is 1 metre distant.

$\frac{O\,M}{O\,C'} = \frac{32}{1000} = .032$ = the sine of 1-metre angle. This corresponds to 1° 50′.

If the eye is directed to a point $\frac{1}{2}$ metre distant, C'', the visual line will deviate twice as much; that is, it deviates 32 mm. at $\frac{1}{2}$ metre distance. If the point of fixation is only $\frac{1}{10}$ of a metre distant, the amount of convergence will equal 10-metre angles.

To find the value of this in degrees we employ the same formula as above—

$\frac{O\,M}{O\,C^{10}}$ = sine of angle $O\,C^{10}\,M$. $O\,M = 32$. $O\,C^{10} = \frac{1}{10}$ metre = 100 mm. $\frac{32}{100} = .32$, the sine of angle of convergence, = 18° 40′.

The value of the metre angles in degrees is obtained very nearly by multiplying 1° 50′ by the number of metre angles. The value of the metre angle varies with the interocular distance, and as there is considerable difference in this distance a separate calculation is necessary for each individual.

A more simple method of determining the value of the metre angle is to find its relation to the centrad. The centrad is a prism which deviates a ray the $\frac{1}{1000}$ part of the radius, measured on the arc (see page 24). The deviation of the metre angle is

measured on the sine. For the angles obtained the sine and arc are almost equal.

One-metre angle equals a deviation of 32 mm. (the average distance between the centres of rotation of the eyes being 64 mm.) at 1 metre distance = 32 in 1000 mm., or 3.2 in 100 = 3.2 centrads. One centrad = .57295°, 3.2 centrads = 1° 50′. Ten-metre angles equal a deviation of 32 mm. in $\frac{1}{10}$ metre, 100 mm., 32 in 100, or 32 centrads = 18° 20′. A 32-centrad prism not only gives us the value of 10-metre angles of convergence, but placed before the eye, with the base inwards, it takes the place of 10-metre angles of convergence, so that the eye, without any convergence, would see an object on the line $C'M$, 10 centimetres distant, as if it were situated at a remote distance.

The convergence becomes *greater* as the point of fixation approaches *nearer*. The number of metre angles is, therefore, inversely proportional to the distance expressed in metres. We thus designate the convergence in terms which indicate the same number of units of convergence as the dioptres of accommodation necessary for the same distance. An emmetrope, in looking at an object $\frac{1}{4}$ metre distant, would employ 4-metre angles of convergence, and 4 dioptres of accommodation.

The **amplitude of convergence** is the number of metre angles of convergence which the eyes can call into action. It is measured from the *far point of convergence* to the *near point of convergence*.

The far point of convergence is the point to which the visual lines are directed when the convergence is relaxed to its utmost; the near point of convergence is the point to which the visual lines are directed when the convergence is at its maximum. If in the minimum degree of convergence, the visual lines are parallel, the far point is infinite; convergence will then be equal to accommodation. The visual lines may diverge considerably in the minimum of convergence constituting an outward squint and converge by their posterior extremities; the far point is negative, and the convergence is insufficient at any point for which the eyes are accommodated. With the convergence relaxed to its fullest extent the visual lines sometimes deviate inwards, constitu-

ting an internal squint. The convergence will in such a case always be in excess of the accommodation.

The two functions of convergence and accommodation, while closely associated, still have some latitude of movement; it is possible to accommodate several dioptres without any convergence, and to converge several metre angles without accommodation. At the far point of accommodation and convergence the accommodation has somewhat more play; at the near point, however, the convergence has much the larger movement. The amplitude of convergence does not diminish with age as does the accommodation.

CHAPTER II.

EXAMINATION OF THE PATIENT AND EXTERNAL EXAMINATION OF THE EYE.

A SYSTEMATIC method of examination of each case should be practised in order to secure the preservation of careful records. For this purpose the following order of examination may be used :[1]—

Name and residence.

Age, sex, race, married or single.

Family history : hereditary tendencies ; general and ocular health of parents, brothers, sisters, etc.

Personal history : children, their number and health ; miscarriages ; former illnesses ; syphilis and gonorrhœa ; injuries.

Occupation : relation of work to present indisposition.

Habits : brain use ; tobacco ; alcohol ; narcotics ; sexual.

Date and mode of onset and supposed cause of present trouble ; outline of its course.

Organs of digestion : teeth ; tongue ; stomach ; bowels.

Organs of respiration : nose ; throat ; lungs.

Organs of circulation : heart ; pulse ; blood.

Kidneys : examination of urine.

Abdominal organs : liver ; spleen.

Organs of generation : menses ; leucorrhœa ; uterine disease.

Nervous system : intelligence ; evidences of hysteria ; hallucinations ; sleep ; vertigo ; gait ; station ; tendon and muscle jerks ; paralysis ; tremor ; pain ; subjective sensations ; convulsions ; headaches and their position.

Eyes : inspection of the skull and orbits (symmetry or asymmetry) ; lids ; ciliary borders ; puncta lachrymalia ; upper and lower cul-de-sacs ; conjunctivæ ; caruncles ; corneæ (oblique illumination) ; irides (mobility and color) ; anterior chambers (depth and character of contents) ; vision ; accommodation ; balance and parallelism of external eye muscles ; mobility of globe ; tension ; light sense ; color sense ; fields of vision ; ophthalmoscope.

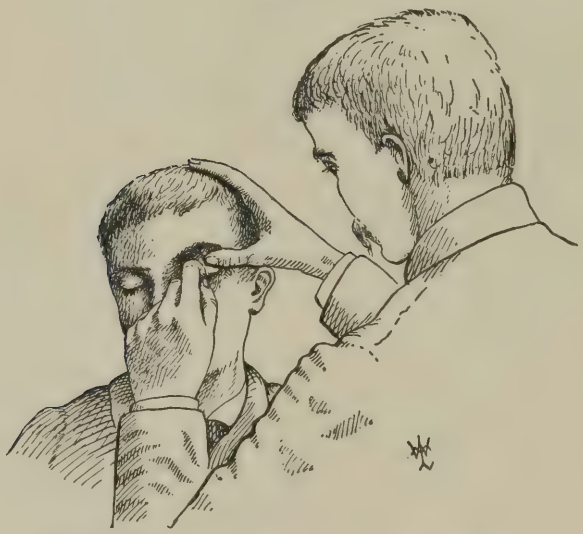
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[1] This order of examination is modified from the one employed by Dr. Weir Mitchell in the Infirmary for Nervous Diseases.

This schedule of examination must be modified to suit individual cases, as these present trivial local lesions directly discoverable by inspection, or forms of disease requiring detailed study for their proper interpretation.

Direct Inspection of the Eye.—After the preliminary examination which the case demands, the surgeon proceeds to the direct inspection of the eye. The surfaces of the lids should be examined for swollen superficial veins, a common index of inflammation of the globe; their edges for inflammation, parasites, and misplaced cilia; the puncta for permeability, pressure at the same time being made over the lachrymal sac in order to express from it through the puncta any contained fluid; the upper and lower conjunctival cul-de-sac for accumulated secretion, granulations, and foreign bodies; the palpebral conjunctiva for hardened secretion in glands; the caruncles for swelling, attached foreign bodies, and irritation by incurved cilia; and the conjunctiva for the information to be derived from its bloodvessels.

Fig. 26.

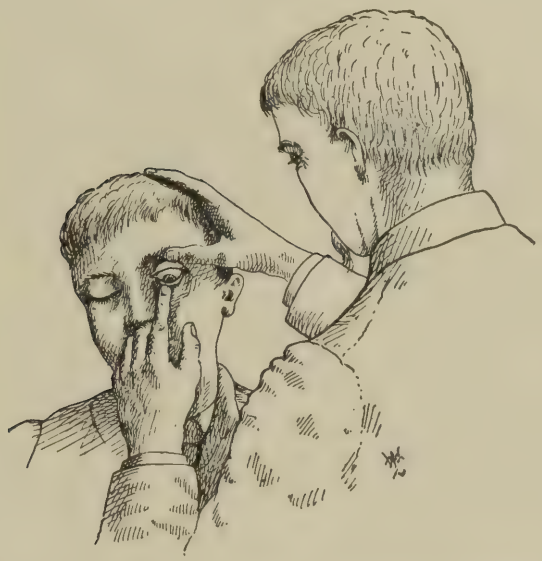


Position of hands in the act of everting the eyelid.

In order to evert the lid, observe the following rules: Require the patient to turn the eye strongly downward, seize gently the

central eyelashes of the upper lid between the index finger and thumb of the left hand, draw the lid downward and away from the ball, place the point of the thumb of the right hand above the tarsal cartilage of the lid which is to be everted, the remaining fingers being steadied on the brow, and by a quick move-

Fig. 27.



Eyelid everted for examination of its under surface and the upper part of globe.

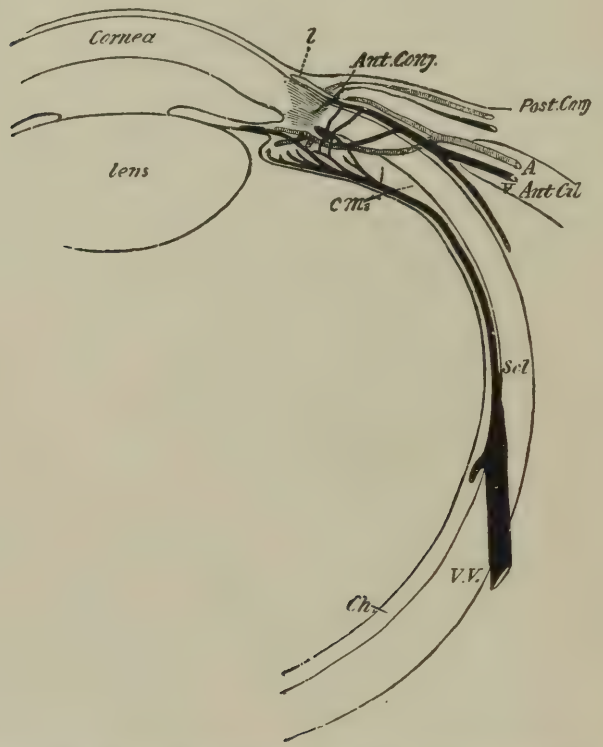
ment turn the edge of the lid over the point of the thumb, while this is simultaneously depressed. During the entire manœuvre insist upon the downward direction of the patient's eyes; otherwise, the lid cannot be turned without undue force and pain.

Bloodvessels of the Conjunctiva.—In health only a few conspicuous bloodvessels are to be observed; in inflammation many more become visible. The arteries of the conjunctiva are derived from the palpebral and lachrymal branches of the ophthalmic; those of the episcleral tissue arise from the anterior ciliary branches of the ophthalmic, while the border of the cornea is surrounded by a plexus of capillary loops derived from the anterior ciliary ves-

sels. This blood supply may be conveniently divided, as Mr. Nettleship has done, into three systems :—

System I. Posterior conjunctival vessels, whose congestion produces a bright red, velvety color, moving, on pressure of the eyelids, with the shifting of the conjunctiva, usually associated with muco-purulent secretion, and indicating ophthalmia.

Fig. 28.



Vessels of the front of the eyeball. *cm*, ciliary muscle. *Ch*, choroid. *Scl*, sclerotic. *V V*, vena vorticosa. *l*, marginal loop-plexus of cornea. *Ant.* and *Post. Conj.*, anterior and posterior conjunctival vessels. *Ant. Cil. A.* and *V*, anterior ciliary arteries and veins. (After Nettleship's alteration from Leber.)

System II. Anterior ciliary vessels, composed of perforating and non-perforating arteries and veins. The perforating arteries, which supply the sclerotic, iris, and ciliary bodies, are the branches seen in health entering about 5 mm. from the corneal margin, their

points of entrance, in dark-complexioned people, often being distinctly tinted.

The non-perforating (episcleral) branches, invisible in the normal eye, produce, when congested, a pink zone surrounding the cornea ("ciliary congestion," "circum-corneal zone"), not moving on pressure of the lids with the shifting of the conjunctiva, unassociated with purulent discharge, and indicative of iritis.

The perforating veins and their non-perforating (episcleral) twigs, when congested, create a zone of dusky hue, often a symptom of glaucoma, or appear in unequal deep-seated patches of lilac or violaceous color, pointing to cyclitis or scleritis.

System III. Anterior conjunctival vessels and the plexus of capillaries surrounding the cornea, derived from anterior ciliary vessels through whose numerous small branches anastomosis between System I. and II. takes place. Their congestion produces a circle of bright-red injection, often partly on the cornea, a sign of inflammation of this membrane, and typified in the early vascular stages of interstitial keratitis. (See page 285.)

In addition to these three varieties of congestion numerous departures are noticeable, making it impossible to separate the form and specify the individual system involved. In these types is found a definite local injection, like the leash of vessels passing to a corneal ulcer; or all the systems are commingled in a general inflammation.

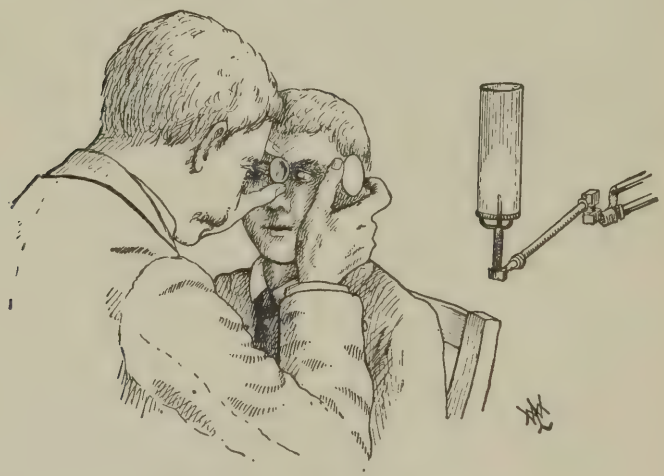
Inspection of the Cornea reveals inflammation, ulceration, opacities, and foreign bodies. Slight irregularities are detected by placing the patient before a window, while the eyes are made to follow the uplifted finger held about one foot from the face, and moved in various directions. The image of the window-bars reflected from the cornea will be broken as it crosses the spot of inequality.

A more accurate method is to employ a *keratoscope.* This instrument consists of a disc shaped like a target, upon which are drawn concentric black circles, a sight hole being in the centre. The patient is placed with his back to the window while the surgeon holds the instrument in front of the eye, and, looking through the central aperture, observes the reflections of the circles from the cornea. If these are broken or distorted, the indications of irregularity in the surface are present.

Minute abrasions and ulcers, if suspected, and yet not determined, may be found by dropping into the eye a concentrated alkaline solution of *fluorescin* (Gruebler's fluorescin, 2 per cent.; carbonate of soda, 3.5 per cent.), which colors green that portion of the cornea deprived of its epithelium, while the healthy epithelium remains unaffected. For example, the coloration takes place around a foreign body in the cornea, the foreign body itself appearing as a black dot in the centre of the green area. The observation with fluorescin was made originally by Straub.

Oblique Illumination is a method of examination by which the cornea, the anterior chamber, the iris, and, if the pupil is dilated, the lens and even the anterior layers of the vitreous may be studied. The surgeon places the patient two feet from the source of illumination, and focuses a beam of light with a two-inch or three-inch lens upon the cornea, at the same time observing the surface under examination through a lens of the same focal distance, held between the thumb and forefinger, the disengaged fingers being utilized to elevate the upper lid. (Fig. 29.)

Fig. 29.



Method of oblique illumination.

The distance of the lens must be varied slightly, according as the cornea, iris, or crystalline lens is brought within its focus, the patient being required to look up, down and to either side,

while all the anterior surfaces and media of the eye are illuminated. In order to detect foreign bodies in the cornea, the light should be directed at an acute angle. If the posterior pole of the lens is to be examined, the light is thrown perpendicularly into the pupil, the surgeon placing his eye in the same direction, without interfering with the light.

By this method minute abrasions, previously undetected foreign bodies, channels of old vessels, and other corneal changes may be examined. The character of the aqueous humor, the depth of the anterior chamber, the surface of the iris, the presence of synechiæ, small tumors, atrophic fibres, and persisting pupillary membrane are evident, and, finally, opacities in the anterior capsule and axis of the lens are discoverable.

The routine examination by means of lateral illumination, provided the eye is unaffected with an inflammation associated with so much photophobia that this is not possible, will often afford information unattainable by other methods.

The Corneal Loupe.—This is a lens, properly mounted, by which the cornea is strongly magnified, and which may be employed with oblique illumination. A "corneal microscope," or a specially prepared lens of high power, permits the study of minute changes in this membrane, and is utilized for the examination of the traces of former vascularization, particularly after interstitial keratitis (see page 286), and by its help even the circulation of the blood in the vessels of a pannus may be studied.

The Color of the Iris.—The color of the irides varies; blue and gray are the predominating hues; brown occurs next in frequency; while the various admixtures produce yellow and green shades. Black irides are never seen, and the color of the iris of all new-born children is of a light grayish-blue; the stromal pigment is developed subsequently.[1]

Slight differences in shade between the two irides are not uncommon; more rarely, even in health, the irides differ in color (chromatic asymmetry), one being brown or greenish, the

[1] Ely records two dark irides in more than 1000 newly-born children; in one the child was a negro.

other blue or gray. Almost invariably, in cases of this sort, one iris corresponds in color with the irides of one parent, and the remaining iris with those of the other parent. Instead of uniform pigmentation, a single triangular patch, or several irregular spots of dark color, may appear upon one or both irides (piebald irides). This is sometimes temporary. Chromatic asymmetry, while perfectly compatible with health, has been observed in patients with neuropathic tendencies—chorea and epilepsy—(Féré); in other instances, there is liability to disease on the part of the lighter eye (cataract). This phenomenon may be present in several members of the same family.

Discoloration from disease results in one iris being green, that of the fellow being blue, and indicates iritis or cyclitis; it is often an early symptom of inflammation of the iris, and should be looked for in every inflamed eye. When the dark segments seen in a piebald iris are small, they have been mistaken by incautious observers for foreign bodies.

The Pupil.—The size of the pupil in health varies with exposure to light, and with accommodation and convergence. There is no physiological standard by which to base a measurement. The pupil is generally smaller in old age, in blue irides, and in eyes with hypermetropic refraction; it is larger in youth, in dark irides, and in eyes with myopic refraction. With the accommodation at rest, the diameter of the pupil varies from 2.44 to 5.82 mm., the average diameter being 4.14 mm. (Woinow). The position of the pupil is a little to the nasal side of the cornea, and, under similar illumination, the pupils should be round and of equal size.[1]

It is much to be regretted that the recorded variations in the diameter of the pupil are commonly imperfect, and the loose statements, "pupils dilated," "pupils contracted," "pupils medium-sized," have crept into many reports.

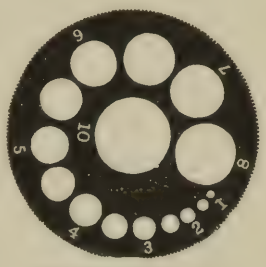
Measurement of the Pupil.—The pupil can be measured approximately by holding before it a rule, marked in millimetres, and noting the number of spaces its width occupies. The chief

[1] In contrast to this statement, the observation of Iwanow deserves mention. This observer found, among 134 healthy young military recruits, equal width of pupil in only 12. The right pupil was larger in 49, and the left in 73.

objection to this method is, that the distance subtended on the rule is less than the diameter of the pupil, in proportion as the distance from the observer's eye is less to the rule than to the pupil (Jackson).

A great variety of instruments, known as pupillometers, have been devised for the accurate measurement of the width of the pupil. A very simple and serviceable device is Randall's modification of Follin's instrument, which consists of a scale of circles held close to the observed eye, the scale being slowly rotated until that circle which matches the pupil in size is reached.

Fig. 30.



Simple pupillometer.

Priestley Smith's *keratometer* is a scale situated between two plano-convex lenses. The surgeon places his eye at the principal focus of the combination, and, holding the scale before the patient's eye, observes that the cornea, or pupil, subtends on the scale exactly its width.

All examinations should be made under a uniformly strong light, and the character of light should be stated.

Mobility of the Iris.—The reflex mobility of the iris is tested to find the presence of attachments between the iris and the lens (synechiæ), or immobility from atrophy of the iris, or to examine the sensitiveness to light of the retina or visual centre.

The patient is placed before a window in diffuse daylight, and one eye is carefully excluded. He is directed to look into the distance with the exposed eye, which is then shaded, and, if it is normal, a considerable dilatation of the pupil will occur. On removal of the covering hand or card, contraction to the same size as that which existed before the test was applied takes place (*direct reflex action of the pupil*). During this examination, the other pupil will act in unison with its fellow (*consensual*, or *indirect reflex action*), and in normal eyes the pupils should be equal, not only with both eyes open, but with one eye shaded.

When the covering hand is removed from the eye directed toward the light, the dilatation which existed in the pupil yields

to a contraction, succeeded in a moment by a slight dilatation and again a contraction, oscillating thus for a moment until it settles to the original size. This is called "*hippus*," a phenomenon seen in an exaggerated degree in hysteria, mania, and other nervous disorders. The explanation of hippus is that each contraction of the pupil, by diminishing the supply of light to the retina, contains in itself the cause of the succeeding dilatation; and, conversely, each dilatation sets in motion the succeeding contraction, until at last equilibrium is attained (Swanzy).

During the whole process of testing the reflex mobility of the iris the observed eye must be steadily fixed upon a distant point; otherwise the influence of accommodation or convergence will arise.

The contraction of the pupil, which occurs when the eye is exposed to a source of light in the manner described, is a reflex phenomenon, the optic nerve being the afferent pathway, and the oculo-motor the efferent nerve going to the sphincter of the iris, the communicating fibres between the corpora quadrigemina and the centre for the third nerve enabling the reflex to take place.

The pupils also contract when the eyes are directed to a near object, or, in other words, contraction takes place under the influence of accommodation and convergence (*associated action of the pupils*). The extent of this action is less than in the reflex motions, and is more closely connected with convergence than with accommodation. Accommodation increases pupillary contraction, but this contraction does not take place under the influence of accommodation unassociated with convergence; it does occur with convergence without the act of accommodation.

Dilatation of the pupil occurs in glaucoma, in cases of non-conductivity of light (atrophy), in orbital disease, and under the influence of mydriatics. It is further seen in fright, emotion, anæmia, in depressed nervous tone, aortic insufficiency, and irritation of the cervical sympathetic.

In diseases of the nervous system, dilatation of the pupil when of cerebral origin indicates extensive lesion; when of spinal origin, irritation of the part (McEwen). Systematic writers have divided dilatation into *irritation mydriasis*, caused by irritation of the

pupil dilating centre or fibres, and *paralytic mydriasis*, caused by paralysis of the pupil dilating centre or fibres.

Contraction of the pupil (*myosis*) appears in congestions of the iris, in certain fevers, in plethora, venous obstruction, mitral disease, pulmonary congestion, paralysis of the sympathetic, and under the influence of myotics.

If the myosis is of cerebral origin, it indicates an early irritative stage of the affection (meningitis, etc.); if of spinal origin, a depression, paralysis, or even destruction of the part (McEwen).

The small pupils connected with degeneration of the posterior columns of the cord (*spinal myosis*), unaffected by the changes of light and shade, but contracting still farther under the influence of convergence of the visual axes, are known as Argyll-Robertson pupils.

Systematic writers divide contraction of the pupil into *irritation* and *paralytic* myosis. The same factors which cause myosis may cause mydriasis, the determining factor being the degree and the duration of the lesion.

Unequal pupils are rarely seen in health.[1] If there is recent wide dilatation of one pupil and no disease of the eye, the instillation of a mydriatic may be suspected. Unequal pupils occur in eyes with widely dissimilar refraction, if one eye is blind, in aneurism, dental disease, traumatism, and in diseases of the nervous system. If the disease is cerebral, the inequality denotes unilateral or focal brain disease. It is not uncommon in tabes, disseminated sclerosis, and paretic dementia. *Varying inequality* of the pupils, or a one-sided mydriasis now occurring on the one side and now on the other, is a serious premonitory symptom of insanity.

Testing Acuteness of Vision.—The acuity of vision is the power of distinguishing form and size, and is a function of the macula lutea, the peripheral portions of the retina having only indifferent ability to distinguish form and size.

In order to determine the acuity of sight test-types are employed, in which the letters are of various sizes, and constructed according to the methods described on page 43.

[1] See foot-note, page 64.

When it is desired to test the acuity of vision the patient is placed six metres from the type-card, in a well-lighted room, and each eye is tried separately. If the letters of No. 6 (twenty feet approximately) are read, vision is normal, or 1, but if, at the same distance, no smaller letters than those numbered 18 (sixty feet) can be discerned, vision is $\frac{1}{3}$. It is usual to express these results according to the formula $V = \frac{d}{D}$, in which V stands for visual acuteness, d for the distance of the patient from the card, and D for the distance at which the type should be read; so that in these instances the vision would be recorded $\frac{6}{6}$ and $\frac{6}{18}$, or in feet, $\frac{20}{\text{XX}}$ and $\frac{20}{\text{LX}}$. The rays coming from the letters at six metres distance have so little divergence when they reach the eye that they may be considered parallel. Hence, if the patient sees distinctly at this distance, his vision is perfect at the longest range.[1] Any other distance may be chosen, provided it does not place the patient closer to the test-card than three metres, at which close range the function of accommodation would introduce an element of inaccuracy. Thus, the scale made use of by De Wecker, and elaborated by Oliver, assumes $\frac{5}{5}$ $\left(\frac{15}{\text{XV}}\right.$ approximately$\left.\right)$ instead of $\frac{6}{6}$, as $\frac{1}{1}$.

The acuity of sight, as tested with types constructed on the basis of an angle of five minutes, does not always yield accurately the highest vision attainable; indeed, many good eyes possess a vision of $\frac{5}{4}$ of the standard angle. For this reason Dr. James Wallace has arranged a series of test-types in which an angle of four minutes has been substituted as the basis of each letter. (Fig. 31.)

For the purpose of a control test, and also for determining visual acuity in illiterate persons, cards are employed on which a number of differently arranged dots are placed, of sizes which should be counted at different distances, and among these Burchardt's international tests are the most useful.

[1] Compare page 47.

If the patient fails to decipher the largest letters at the distance employed, he should be moved closer to the card; thus, he may be unable to read the type numbered 60, at six metres, but may discern this at 4 metres, $V = \frac{4}{60}$ or $\frac{1}{15}$ of normal. Still further depreciation of visual acuity is recorded by requiring the subject to count the outstretched fingers at various distances, 2, 3, or 6 feet, $V =$ counting fingers at 2 feet. When the ability to distinguish form (*qualitative light perception*) no longer exists, the perception of light should be tried by alternately screening and shading the eye, or by illuminating the eye with light reflected from a mirror.

Fig. 31.



Diagram of test-letters reduced one-quarter.

Light-sense.—Having determined the acuity of vision by means of the test-letters, the examiner has ascertained the *form-sense*, and may proceed to try a second subdivision of the sense of sight, the *light-sense*, which is the power possessed by the retina, or centre of vision, of appreciating variations in the intensity of the source of illumination.

An instrument, called a *photometer*, is employed for this purpose, and consists essentially of an apparatus by which the intensity

of two sources of light may be compared. The patient, looking into the instrument, sees two equally bright discs. One disc is now made darker, and the power of the eye to perceive the difference in the illumination of the two discs ascertained; or one disc is made entirely dark, and then gradually illuminated, and the smallest degree of light noted by which the patient can perceive the disc coming from the darkness. The former is called the *light-difference* (L. D.), and the latter the *light minimum* (L. M.). Some information in regard to the light-sense may be obtained by testing the acuity of vision on two cards, under a different degree of illumination, and by comparing the results with a similar examination of a subject believed to have normal power of appreciating different degrees of illumination. Indeed, a very important examination in slight retinal changes and minor disturbances about the macula consists in ascertaining the acuity of sight under full and under diminished illumination.

Color-sense.—A third subdivision of the sense of sight is the *color-sense*, or the power which the retina has of perceiving color, or that sensation which results from the impression of light waves having a certain refrangibility.

This is an extremely important examination, and is of especial interest in the detection of *color-blindness*. (See page 479.)

Method of Holmgren.—In practice the method of Holmgren is most frequently employed. This consists in testing the power of a person to match various colors, conveniently used in the form of colored yarns. The test colors, viz: *light green*, *rose* or *purple*, and *red*, are placed before the patient, who is required to select similar colors from a mass of colored yarns in which a great number of tints are associated in a confused mixture. The examiner decides, in regard to the perfection of the patient's color-sense, by the manner in which he makes the selections, and by the degree of accuracy he exhibits in matching the various tints.

Dr. William Thomson has devised for this purpose a most convenient instrument, composed of a stick with yarns attached, a light green being used as the test-skein. The method is thus described by its author: Using the light-green test-skein, the subject is asked to match it in color from the yarns on the stick, which are arranged in alternate green and confusion colors,

and which are numbered from one to twenty. The selection of ten tints is required, and the examiner notes the numbers of the tints chosen. The odd numbers are green; and the even ones the confusion colors. If the subject has a good color-sense, his record will exhibit none but odd numbers; if he is color-blind, the mingling of even numbers betrays the defect. To distinguish between green-blindness and red-blindness, the *rose-test* is used, and the color-blind subject will select, indifferently, either the blues intermingled with the rose, or, perhaps, the blue-greens or grays. Finally, the *red-test* is used as a control.

Instead of requiring the candidate to match colored yarns, according to the method outlined, or any modification of this, other plans may be pursued.

(1.) **The Lantern-Test.**—The question is often asked whether, in the examination of sailors and railroad employés for the detection of color-blindness, the tests are not of such a character that men, for all practical purposes safe in their chosen occupations, are rejected. In other words, it has sometimes been believed, and often stated, that the tests were so searching that valuable men were discarded, although exhibiting only very slight degrees of deficiency in the color-sense, too slight to render them unfit for railway service.

The detection of color-blindness from a practical point of view has been a subject of considerable study at the hands of F. W. Edridge-Green, who believes that the exclusion of dangerous persons only is essential, and that the possession of slight degrees of color-blindness may be permitted to be passed by, as, for all practical purposes, their subjects are normal-sighted. He has devised an apparatus which consists of a lantern and twelve slides. Six slides contain colored glasses (standard red, yellow, pure green, standard green, blue, and purple), and six contain modifying glasses, that is, glasses which are ground, ribbed, and composed of four thicknesses of a special kind of neutral glass. The object of the test is to ascertain whether the candidate under trial can discriminate between red, green, and white lights. To prevent guessing, the colors before-mentioned, other than red and green, are employed.

Dr. Edridge-Green thus describes the application of his method: The candidate should be seated at a distance of fifteen feet from the lantern. He should be asked to name the color of the light produced by a colored glass alone, or in combination with the modifying glasses. A candidate should be rejected: (1) If he calls the red green, or the green red, under any circumstances; (2) if he calls the white light, under any circumstances, red or green, or *vice versa;* (3) if he calls the red green, or white light black, under any circumstances.

A candidate who makes mistakes other than those mentioned should be put through a very thorough examination. This examination can be made by what Dr. Edridge-Green calls the classification test, which he intends for scientific purposes, and which consists in a series of test and confusion colors, the candidate being required to match the test colors. This examination apparently differs only in the method of its application from such as are well known.

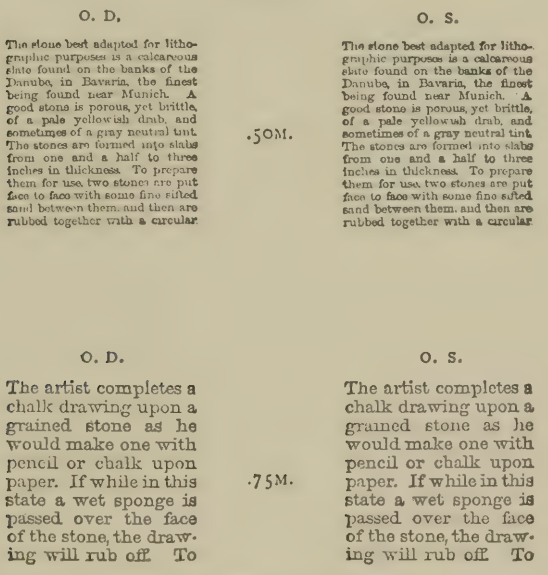
(2) **The Pseudo-isochromatic Plates of Stilling.**—These consist of a series of plates (ten in number), each plate containing four squares filled by small, irregular, colored spots, among which other spots in a confusion color, made to conform to an Arabic figure, are placed. The test-plate is held in a good light, and the examiner requires the subject to distinguish the tracings. These plates are said to be of practical use.

Accommodation has been defined to be those changes in the optical adjustment of the eye effected by the ciliary muscle (Schweigger), and in practice is measured by finding the nearest point at which fine print can be clearly deciphered. The type usually adopted is that known as Snellen's 0.5, or Jäger's 1.

In order to study the phenomena of accommodation the student should record: 1. The nearest point of perfectly distinct vision attainable with the smallest readable type, or the *punctum proximum* (abbreviated *p. p.*, or simply *p.*). 2. The farthest point of distinct vision, or *punctum remotum* (abbreviated *p. r.*, or simply *r.*). 3. The *range, amplitude* of accommodation, or the expression of the amount of accommodative effort of which the eye is capable. This is expressed in the number of that convex lens,

placed close to the cornea, whose focal length equals the distance from the near point to the cornea, and which gives rays a direction as if they had come from the far point; thus, if the near point be 7 cm., the lens which expresses the amplitude of accommodation is + 14 D. $\frac{100}{7} = 14$. 4. The *region*, or the *space* in which this is available. 5. *Relative accommodation*, or

FIG. 32.



Type for testing accommodation.

that independent portion of this function which can be exercised without alteration in a given amount of convergence, and is divided into a *negative* portion, or that portion which is already in use, and a *positive* portion, or that portion which is not in use. (See also page 44.)

Mobility of the Eyes.—This is tested by causing the patient to follow with his eyes, the head remaining stationary, the movements of the uplifted finger which is directed to the right, to the left, upward and downward. Both eyes must be observed, and note made of any lagging in their movements, or of the failure of

either eye readily to turn into the nasal or temporal canthus. At the same time the relation of the movements of the upper lid to those of the eyeball is recorded. The attention of the patient must be centred upon the moving finger, and allowance should be made for the imperfect mobility of highly myopic eyes. Any asymmetry of the skull, or difference in the level of the two orbital margins, may be observed, because such conditions are not infrequently associated with ametropic eyes, especially when the two eyes possess great inequality in refractive conditions.

Balance of the External Eye Muscles.—Under normal conditions perfect equilibrium of the external eye muscles is present, but preponderance, for example, of the power of the external recti (insufficiency of the internal recti), or *vice versa*, produces a tendency to divergence or convergence, which, however, is overcome, with preservation of binocular vision, in spite of the disturbed equipoise. This condition was named by Von Graefe *dynamic strabismus*.

In order to ascertain the condition of the ocular muscles we employ the following tests :—

(1) Approach the finger to within a few inches of the eyes, which are steadily fixed upon its tip, and note if a convergence to a distance of 8 cm. ($3\frac{1}{2}$ inches) is attainable. If, before this point is reached, one eye deviates outward, insufficiency of the interni is present, the eye possessing the weaker internus usually being the one which exhibits the deviation. This test is a rough one, and valuable chiefly for ascertaining which of the interni is the weaker.

(2) Require the patient to fix upon a fine object, like a pin-point, held below the horizontal, 20 or 25 cm. from the eye, and, in order to remove the control of binocular vision, cover one eye with a card or the hand, and observe whether the eye under cover deviates inward or outward, and returns to fixation when the cover is removed.

If the patient fixes the object accurately, and the manipulations of covering and uncovering first one eye, and then the other, are rapidly performed, trustworthy results will be obtained. In general terms, each millimeter of movement of the devi-

ating eye corresponds to 2° of insufficiency as measured by prisms. In the case of the interni, if the covered eye moves in to fix, with several distinct impulses, each impulse should be multiplied into the foregoing result. (Randall.)

(3) Produce vertical diplopia with a prism, and test the functions of the lateral muscles at a distance of 6 metres.

A lighted candle is placed against a dark background at 6 metres from the patient, and on a level with his eyes. In an accurately adjusted trial frame, a prism of 7° is inserted, base down, before one eye, for example the right. Vertical diplopia is induced, and the upper image belongs to the right eye. If the flames stand, one directly over the other, there is no inclination to divergence or convergence. If the upper image stands to the left, there is weakness of the interni; if to the right, of the externi. That prism placed with its base in or out before the left eye, according to circumstances, which brings the two images into a vertical line, measures the degree of the deviation.

Thus the presence or absence of *lateral insufficiency* is determined.

(4) Produce lateral diplopia, and test the functions of the vertical muscles at a distance of 6 metres.

The patient is seated opposite a candle, as before, and a prism of sufficient strength to induce homonymous diplopia (8° will usually suffice) is placed before one eye, for example, the right, *i. e.*, the prism is placed with the base towards the nose. If the images are on the same level, no deviating tendency is present. If the right image rises higher than the other, the visual line of the right eye tends to be lower than that of its fellow, and there is *insufficiency of the vertical muscles.* That prism placed with its base down before the left eye, which restores the images to the horizontal level, measures the degree of deviation.

(5) Produce vertical diplopia, and test the functions of the lateral muscles at the ordinary working distance, or 30 cm.

For this purpose it is customary to employ the equilibrium test of Von Graefe, in which a card having upon it a large dot, through which a fine line is drawn, is held 25 or 30 cm. from the eyes,

diplopia being induced by means of a prism of 10° or 15°, base up or down, before one eye. A more accurate test-object is a small dot and fine line, or a single word printed in fine type, requiring accurate fixation and a sustained effort of accommodation. If, the prism being placed base down before the right eye, the images stand exactly one above the other, equilibrium is evident; if the upper image (image of the right eye) stands to the left of the lower image, there is *crossed lateral deviation;* and that prism, placed before the left eye with its base towards the nose, which restores the images to a vertical line, measures the tendency to divergence, or insufficiency of the internal recti. If the upper image stands to the right of the lower, there is *homonymous lateral deviation;* and the prism, placed before the left eye with its base towards the temple, which restores the images to a vertical line, measures the tendency to convergence, or insufficiency of the external recti.

(6) Ascertain the power of adduction, abduction, and sursumduction by finding the strongest prism which the lateral and vertical muscles can overcome (see page 507).

Beginning with *adduction*, find the strongest prism placed before one eye, with its base towards the temple, through which the candle flame still remains single. The test should begin with a weak prism, the strength of which is gradually increased until the limit is ascertained. This varies considerably, from 30° to 50°, and no fixed unit is defined. The muscles may be trained to overcome much higher degrees than those stated.

In like manner *abduction* is tested, the prism now being turned with its base toward the nose; 6° to 8° of prism should be overcome. The ratio between adduction and abduction should be 6 to 1, *i. e.*, if adduction is 48°, abduction should be 8°.

Sursumduction, or the power of uniting the image of the candle flame, seen through a prism placed with its base downward before one eye, with the image of the same object as seen by the other eye, is ascertained by beginning the trial with a weak prism, $\frac{1}{2}$° or 1°, and gradually increasing its strength. The limit is usually 3°, but may be as high as 8° or 10°.

If the eyes of the patient under examination are ametropic,

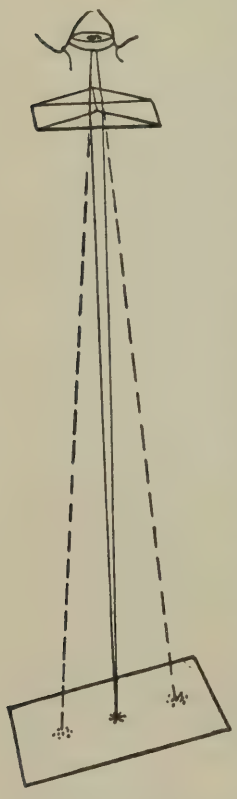
the proper correcting lenses should be placed before them, and the examination for the various forms of insufficiency made through this glass. It is, moreover, exceedingly important that the correcting glass should be accurately centred. Any failure of this, in a lens of considerable thickness, would induce a prismatic effect, which would utterly preclude accurate determination of the muscular conditions, especially of the vertical muscles, where the search for fractions of a degree of deviation are sometimes necessary.

If the muscular examinations have been undertaken as part of a routine preliminary examination of an eye, they should be repeated after the refraction has been accurately determined, and, if anomalous, corrected.

Practically, all of the examinations for muscular errors can be made with a series of prisms and a trial frame. These determinations are facilitated by the use of certain instruments of precision. A time-saving apparatus is the *revolving prism* of Crêtes, or the *rotary prism* devised by Risley. The latter consists of two prisms, superimposed with their bases in opposite directions, constituting a total value of forty-five degrees. They are mounted in a cell which has a delicately milled edge, and fits in the ordinary trial frame. The milled edge permits convenient turning in the frame, so that the base or apex of the prisms can be readily placed in any desired direction. The prisms are caused to rotate in opposite directions by means of a milled screw head, projecting from the front of the cell. Either with this instrument, or with the revolving prism of Crêtes, the strength of the abducting and adducting muscles can be measured. If the rotary prism is placed before the left eye with the zero mark vertical, and the screw turned to the right or left, it will cause the base of the resulting prisms to be either inward or outward, that is, toward the nose or temple, as may be desired.

One of the simplest tests of the ocular muscles is the *obtuse-angled prism* of Maddox. This is composed of "two weak prisms of three degrees, united by their bases. On looking through the line thus formed, at a distant plane, two false images

Fig. 33.



Position of the images as seen through the obtuse-angled prism of Maddox (Randall).

of it are seen, one higher and one lower than the real image seen by the other eye, the position of which, to the right or the left of the line between the false images, indicates the equilibrium of the eye. A faint band of light, of the same breadth as the two false images, is seen extended between them." (Fig. 33.) The answers of the patient may be materially assisted by placing a red glass before one eye, and thus tinting the real image. If this stands directly in the centre between the two false images, all forms of insufficiency are eliminated; if it stands to the right or to the left, there is insufficiency either of the external or of the internal recti; if it stands above or below the centre, or is fused with either the upper or the lower image, there is insufficiency of the superior or inferior recti.

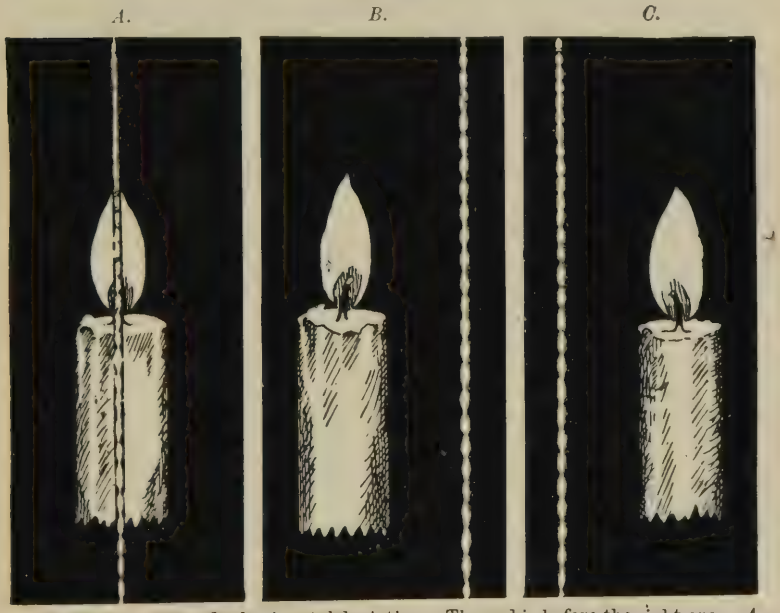
The Maddox prism may be mounted in a cell and placed before the right eye, while the rotary prism of Risley is put before the left eye, and, with this combination in a trial frame, a rapid determination of the degrees of deviation may be made. If the two false images stand to the left of the real image, that degree of prism, found by turning the base of the revolving prism toward the nose on the left side, which brings the three images in line, measures the amount of divergence; if the two false images stand to the right of the real image, that degree of prism, found by turning the base of the rotary prism toward the temple, indicates the amount of convergence.

The *rod test*, also designed by Maddox, depends upon the property of transparent cylinders to cause apparent elongation of an object viewed through them, so that a point of light becomes a line of light so dissimilar from the test-light that the images

are not united. It may be suitably employed by having mounted in a cell, which will fit in the trial frame, a transparent glass rod ¾ of an inch long, and about the thickness of the ordinary stirring rod used by chemists.

The examination for *horizontal deviation* is thus described: "Seat the patient at 6 metres from a small flame, and place the rod horizontally before one eye, a colored glass before the other. If the line passes through the flame, there is orthophoria (equipoise), as far as the horizontal movements of the eyes are concerned. Should the line lie to either side of the flame, as in most people it will, there is either latent convergence or latent divergence; the former, if the line is the same side as the rod (homonymous diplopia); the latter, if to the other side (crossed diplopia)."

FIG. 34.



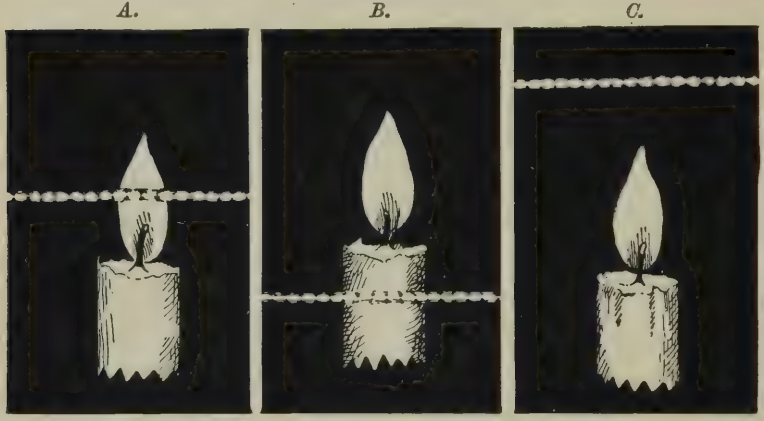
Maddox's rod test for horizontal deviation. The rod is before the right eye. *A.* The line passes through the flame—orthophoria. *B.* The line passes to the right of the flame—latent convergence, or esophoria. *C.* The line passes to the left of the flame—latent divergence, or exophoria.

In order to test the *vertical deviation*, the rod is placed vertically before the eye; a horizontal line of light appears, and the

patient is asked if the line passes directly through the flame, or if it appears above or below it. The following rule, quoted from Maddox, will suffice to indicate the "hyperphoric" eye: "If the flame is lowest, there is a tendency to upward deviation of the naked eye; if the line is lowest, of the eye before which the rod is placed."[1]

The measurement of the extent of the deviation may be made in the ordinary way, by finding that prism, placed before the naked eye (or the eye covered with a red glass), which brings the line and flame together.

FIG. 35.



Maddox's rod test for vertical deviation. The rod is before the right eye. *A.* The line passes through the flame—orthophoria. *B.* The line passes below the flame. The upper image belongs to the left eye—right hyperphoria. *C.* The line passes above the flame. The upper image belongs to the right eye—left hyperphoria.

In order to avoid the awkwardness of the phraseology "insufficiency of the internal recti, etc," and at the same time more accurately to describe the muscular anomalies, the following terminology has been introduced by Dr. George T. Stevens, and has received a wide acceptation:—

"The condition in which all adjustments are made by muscles in a state of physiological equilibrium is called *orthophoria*.

[1] Dr. Swan M. Burnett substitutes for the Maddox rod a 6 D cylinder.

Disturbances of equilibrium are known as *heterophoria*, or insufficiencies of the ocular muscles.

The deviating tendencies of heterophoria may exist in as many directions as there are forces to induce irregular tensions.

The following system of terms is applied to the various tendencies of the visual lines :—

I. Generic Terms.—*Orthophoria:* A tending of the visual lines in parallelism. *Heterophoria:* A tending of these lines in some other way.

II. Specific Terms.—Hetrophoria may be divided into—

1. *Esophoria:* A tending of the visual lines inward.
2. *Exophoria:* A tending of the lines outward.
3. *Hyperphoria* (right or left) : A tending of the right or left visual line in a direction above its fellow.

This term does not imply that the line to which it is referred is too high, but that it is higher than the other, without indicating which may be at fault.

III. Compound Terms.—Tendencies in oblique directions may be expressed as *hyperesophoria*, a tending upward and inward ; or *hyperexophoria*, a tending upward and outward. The designation 'right' or 'left' must be applied to these terms."

Power of Convergence.—In order to determine the maximum of convergence, an instrument, known as an *ophthalmo-dynamometer*, may be employed. The one devised by Landolt consists of a metallic cylinder, blackened on the outside, placed over a candle flame. The cylinder contains a vertical slit, 0.3 mm. wide, covered by ground glass. The luminous vertical line thus produced is the object of fixation. Beneath the cylinder is attached a tape measure graduated on one side in centimetres, and on the other in the corresponding number of metre-angles. The fixation object is gradually approached in the median line towards the patient, until that point where double vision occurs is reached, or the nearest point (*punctum proximum*) of convergence, and the distance in centimetres read from one side of the tape, and the corresponding maximum of convergence in metre-angles on the other.

The minimum of convergence may also be ascertained with the instrument, but when this is *negative* it is determined by finding the strongest abducting prism which will not cause diplopia while the patient is fixing a candle flame at 6 metres. If the number of the prism is divided by 7, the quotient will approximately give in metre-angles the amount of deviation of

each eye when the prism is placed before one. The amplitude of convergence is equivalent to the difference between the maximum and minimum of convergence.[1] (See metre-angles, page 54.)

The Field of Vision.—When the visual axis of one eye is directed to a stationary point, not only is the object thus "fixed" alone visible, but also all other objects contained within a given space, which is large or small, in proportion to the distance of the fixation point from the eye. This space is the *field of vision;* and the objects within it imprint their images upon the peripheral portions of the retina, or those which are independent of the macula lutea. In contradistinction to visual acuity and refraction, which pertain to the macula in the act of *direct vision*, the function of sight capable of being performed by the rest of the retina is called *indirect vision.*

The limits of the visual field may be roughly ascertained in the following manner: Place the patient with his back to the source of light, and have him fix the eye under examination, the other being covered, upon the centre of the face of the observer, or upon the eye of the observer which is directly opposite his own, at a distance of two feet. Then let the surgeon move his fingers in various directions, midway between himself and the patient, on a plane with his own face, until the limits of indirect vision are determined, controlling at the same time the extent and direction of the movements by his own field of vision. This method suffices to discover any considerable limitation, and, in the event of such discovery, should be supplemented by a more exact procedure.[2]

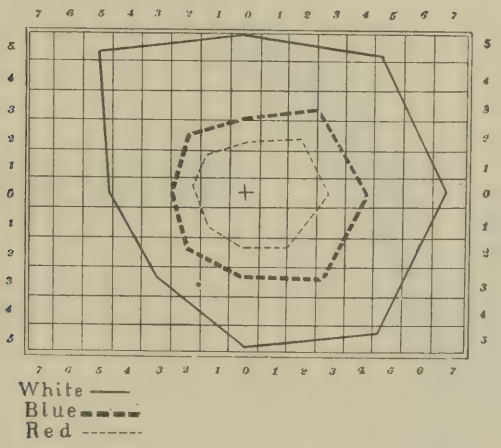
If it is desired to have a map of the field not larger than 45 degrees in extent, let the patient be placed twenty-five centimetres from a blackboard, which may be conveniently ruled in squares, and fix the eye under observation upon a small white mark. The observer then moves the test object, a piece of white paper one centimetre square, affixed to a black handle, from the periphery

[1] Landolt's Refraction and Accommodation of the Eye.

[2] In the systematic examination of the eye, it is not usual to map out the field of vision before an ophthalmoscopic examination has been made; but the description of the methods is conveniently placed here.

toward fixation, until the object is seen. If eight peripheral points are marked, and afterwards joined by a line, a fair map of the field of vision will be obtained.[1]

Fig. 36.



Limits of the normal field for white, blue, and red, transcribed upon a blackboard.

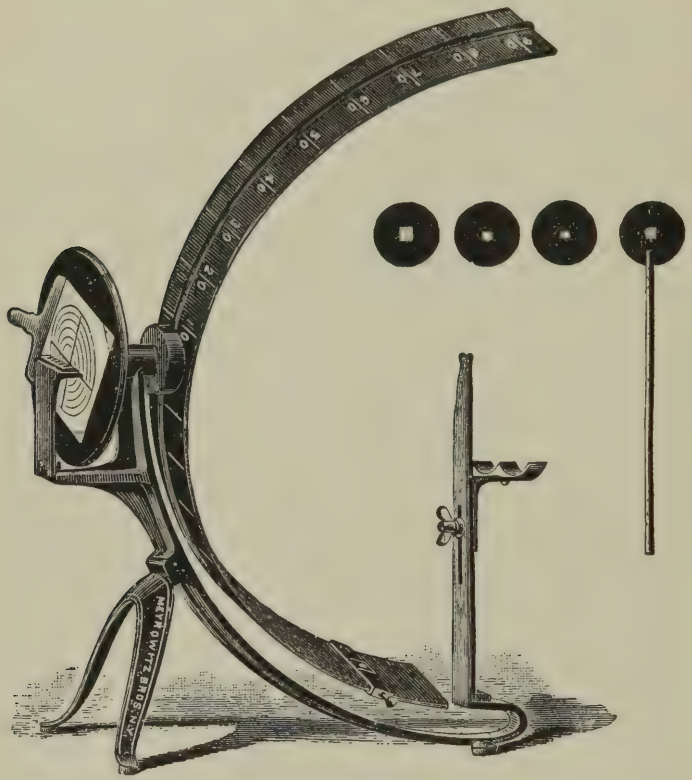
Beyond 45 degrees this method ceases to be accurate, because on a flat surface the object is too far away from the eye; rays perpendicular to the visual line coming from a peripheral object would be parallel to the blackboard, and could not arise from it, or any object passed across its surface (consult Fig. 39).

[1] The value in degrees of the squares on the blackboard may be ascertained by the following table, provided the eye is placed exactly at 25 centimetres from the fixation point:—

2.2 centimetres	=	5 degrees	in	the	perimeter	semicircle.
4.4 "	= 10	"	"	"	"	
6.7 "	= 15	"	"	"	"	
9.1 "	= 20	"	"	"	"	
11 7 "	= 25	"	"	"	"	
14.4 "	= 30	"	"	"	"	
17.5 "	= 35	"	"	"	"	
21 "	= 40	"	"	"	"	
25 "	= 45	"	"	"	"	
30 "	= 50	"	"	"	"	
36.7 "	= 55	"	"	"	"	
43.3 "	= 60	"	"	"	"	

Hence, the investigation of the periphery of the retina requires the use of an instrument, known as a *perimeter*. This consists

Fig. 37.



Perimeter.—The examination may be made with the carrier which moves along the semicircle, or the test objects may be carried along this by means of dark discs attached to a long handle, each disc containing in its centre the test object. The patient's chin is placed in the curved chin-rest; the notched end of the upright bar is brought in contact with the face, directly beneath the eye to be examined, which attentively fixes the centre of the semicircle. The other eye should be covered, preferably with a neatly adjusted bandage. The record-chart is inserted at the back of the instrument, and, by means of an ivory vernier, the examiner is enabled to mark exactly with a pencil the point on the chart, corresponding to the position on the semicircle, at which the patient sees the test object. The various marks are then joined by a continuous line, and a map of the field is obtained (see Fig. 38).

essentially of an arc marked in degrees, which rotates around a central pivot, that at the same time may be the fixing point of

the patient's eye, which is placed 30 centimetres distant (the centre of curvature of the perimeter arc), or the eye may be directed upon a porcelain button on a bar, placed 15 degrees from the centre, to the left, if the right eye is to be examined; *vice versa*, if the left is under observation. The test object, one to two centimetres in diameter, affixed upon a carrier, is moved from without inward, and the point noted in each meridian where it is recognized. The result is transcribed upon a chart, prepared by having ruled upon it radial lines to correspond to the various positions of the arc, and concentric circles to note the degrees.

Many ingenious instruments have been devised, especially such as are self-registering, among which may be mentioned those of McHardy, Stevens, and Priestley Smith.

The physiological limits of the form field, or, what is practically the same thing, the field when this has been mapped with a square of white, are: outward, 90; outward and upward, 70; upward, 50; upward and inward, 55; inward, 60; inward and downward, 55; downward, 72; downward and outward, 85.[1]

These measurements, which vary within normal limits, transcribed upon a chart, produce the following figure. (Fig. 38.)

From this it is evident that the field of vision is not circular, being greatest in extent outward and below, and most restricted inward and above. This restriction is partly due to the presence of

[1] Bjerrum proposes an addition to the usual method of examining the field of vision, a description of which is condensed from Berry's translation of the original paper: The addition consists in making use of white objects which subtend a very small visual angle. The examinations are made at a distance of two metres, using a large black screen, two metres in breadth, which can be let down from the ceiling to the floor. At this distance the blind spot (see page 90) instead of measuring 2.5 cm., as on an ordinary perimeter, measures 20 cm. in diameter; and everything else is in the same proportion.

The objects used by Bjerrum are small circular disks of ivory, fixed on the end of a long, dull black rod. They vary from 10 to 1 mm. in diameter. The examination is begun in the ordinary manner (at 30 centimetres), with the 10 mm. disc, and then continued at 2 metres distance with a 3 mm. disc. In the first case, the visual angle approximately is 2°, in the second 5′. The normal boundaries in the first instance have been given; in the second they are 35° outwards; 30° inwards; 28° downwards; and 25° upwards. Small concentric limitations are unimportant, but the method is valuable in finding sector-shaped defects, irregular limitations, and scotomata (page 89).

the edge of the orbit and the nose, and partly, as Landolt has pointed out, because the outer part of the retina is less used than the

Fig. 38.

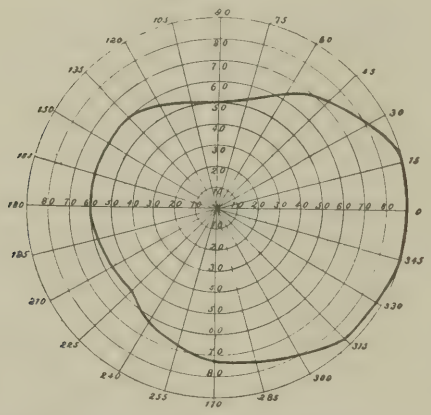
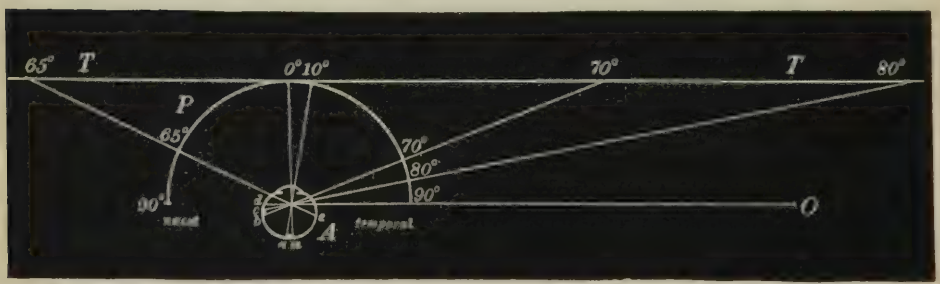


Diagram of the field of vision for white (1 centimetre square test object), transcribed upon a perimeter chart.

inner, and its functions, therefore, are less developed. Hence, as each portion of the field corresponds to the opposite portion of the retina, the inner part is smaller than the outer. To avoid the influence of the physical obstacles afforded by the cranial bones,

Fig. 39.



Projection of the field of vision upon the semicircle of a perimeter. (Fuchs.)

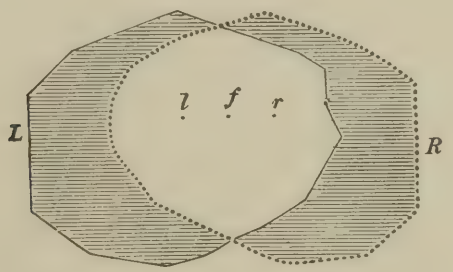
the eye should be made to fix an object, in each meridian, 30° in the direction opposite to that under measurement.

The accompanying diagram, taken from Fuchs, illustrates the

projection of the field of vision of the eye, *A*, upon the semicircle of the perimeter *P*. This extends from 65°, on the nasal side, to 90° on the temporal side, and corresponds to the points *e* and *d* of the retina, which indicate the anterior border of the sensitive retina, reaching farther forward on the nasal than on the temporal side. It also illustrates that the field of vision cannot be recorded up to its temporal limits on a plane surface (see page 83).

Binocular Field of Vision.—The field of vision for each eye having been defined, it remains to point out that the field of vision which pertains to the two eyes, or that portion in which binocular vision is possible, constitutes only the area where the central and inner parts overlap. This is evident from the diagram. The continuous line *L* bounds the field of vision of the left eye, and the dotted line *R* the visual field of the right eye. The central white area corresponds to the portion common to both eyes, or to that area in which all objects are seen at the same time with both eyes; the shaded areas correspond to the portions in which binocular vision is wanting. In the middle of the white area lies the fixation point *f*, and on each side of it the blind spots of the right and left eye, *r* and *l*.

Fig. 40.



Binocular field of vision. (Möser.)

Having thus determined the *limits* and *continuity* of the visual field, the functions of the peripheral parts of the retina in regard to perception of colors, acuity of vision, and appreciation of light should be investigated.

The *color field* is mapped in the manner described in connection with the general visual field, the squares of white in the carrier

of the instrument being replaced by pieces of colored paper one centimetre in diameter.

The order in which the colors are recognized from without inwards is (1) blue, (2) yellow, (3) orange, (4) red, (5) green, (6) violet. In practical work, blue, red, and green are the colors employed, red and green being the color sense most usually affected in pathological cases. The colors are not correctly recognized when the object is first seen. Thus, yellow at first appears white; orange, yellow; red, brown; green, white, gray or gray-blue; and violet, blue. The physiological limits of the color fields, which, like those of the general field, are subject to variations, correspond closely to the following :—

	Blue.	Red.	Green.
Outward	80	65	50
Outward and upward	60	45	40
Upward	40	33	27
Upward and inward	45	30	25
Inward	45	30	25
Inward and downward	50	35	27
Downward	58	45	30
Downward and outward	75	55	45

These, when transcribed upon a chart, are represented in Fig. 41.

The numbers represent the usual limits at which the color is recognized as such. They do not indicate its greatest intensity, which is perceived only at the fixation point. In order to avoid discrepancies, the character of the light, the nature of the color, and its distance from the eye should be carefully stated in describing examinations.

The *acuity of the vision* of the *peripheral parts of the retina* may be ascertained by introducing into the carrier of the instrument small squares of black paper, separated from each other by their own width, and by noting the point in each meridian where they are recognized as separate objects.

The *perception of light*, according to the experiments of Landolt, is the most constant function of the healthy retina, and remains nearly the same throughout its surface, while the color and form-sense rapidly lessen toward the periphery. For practical purposes, a candle flame passed along the arm of the peri-

meter may be used as a test-object; and, if vision is very defective, a second candle is made the point of fixation.

The methods described serve to determine the general visual field, the color field, and any departure from those limits which have been assumed to be physiological.

FIG. 41.

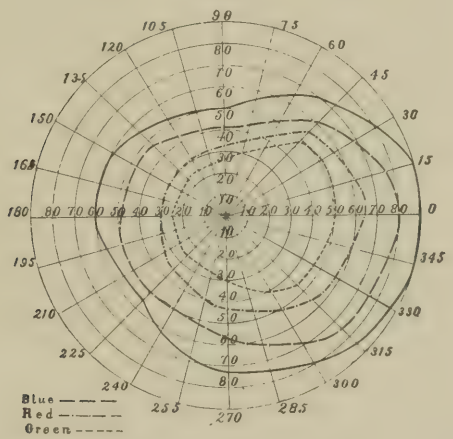


Diagram of the field of vision for blue, red, and green. The outer continuous line indicates the limit of the form field; the broken lines the limits of the color fields.

The most frequent departures are general or concentric contraction—contraction limited especially to one or the other side; peripheral defects in the form of re-entering angles; absence of one segment or quadrant; and absence of the entire right or left half of the field.

In addition to these defects, search should be made for dark areas within the limits of the visual field, or *scotomata*. These are distinguished as *positive*, when they are appreciated by the patient, and *negative*, when he is not conscious of their existence; the latter are color scotomas, usually for red and green. They are further subdivided, according to their situation and form, into *central*, *paracentral*, *ring*, and *peripheral*.

In every normal eye there is a physiological scotoma, corresponding to the position of the optic nerve entrance, which usually may be found 15° to the outer side of, and 3° below, the

point of fixation; the distance from fixation being greater in hypermetropic than in myopic eyes. This is known as *Mariotte's blind spot.*

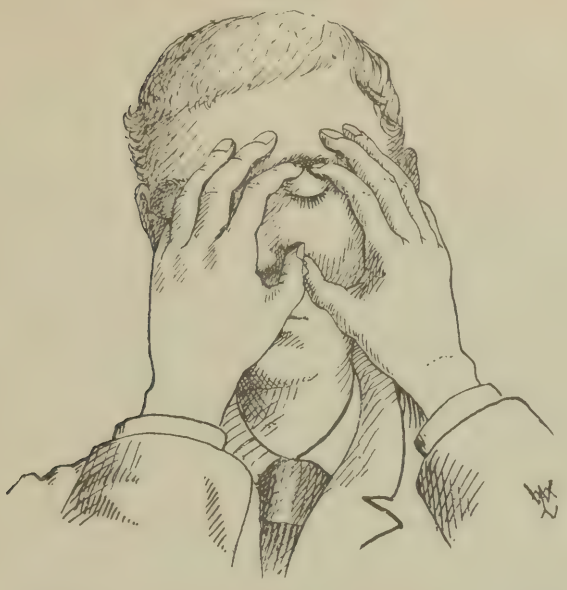
For the detection of scotomata, small test objects, white or colored, $\frac{1}{4}$ of a centimetre square, are employed, which are moved in different directions from the point which the eye under observation attentively fixes, and the spot marked where the object begins to disappear or change its color. The arm of the perimeter is usually marked near the centre in half degrees for this purpose. All examinations around the centre of the field of vision, and hence the examination for scotomata, are readily made upon the blackboard.

Berry urges that the ordinary test for scotomas be supplemented by making an examination of the particular area of the field at a distance of 2 metres or more, so as to obtain a larger projection of the blind portion, and to be able to work with smaller retinal images, without necessitating the use of very small objects.

Tension.—This term indicates the intraocular resistance, and is clinically demonstrable by palpating the globe with the finger tips. The middle and ring fingers are placed upon the brow of the patient, the tips of the index fingers upon the eyeball, and gentle to-and-fro pressure made, the eyes being directed downward. This pressure must be made in such a manner as not to push the ball into the orbit; otherwise no information of its true resistance is obtained. The tension of one eye must always be compared with that of its fellow, and, in any doubtful case, the results may be contrasted with those obtained by examining an eye known to be normal in another patient of similar age.

Normal tension is expressed by the sign Tn, and the departures from it by the symbols +?, + 1, + 2, + 3, and —?, — 1, — 2, — 3; the plus signs indicate increased, and the minus signs decreased resistance. In physiological experiments, various kinds of apparatus, constructed upon the principle of the manometer, are employed, and for clinical purposes instruments known as *tonometers* have been devised. In practical work, however, sufficiently accurate data are obtainable by a careful use of the educated finger tips.

Fig. 42.



Position of hands in determining the tension of an eyeball.

Proptosis, or protrusion of the eye, may be caused by orbital diseases, tenotomy, paralysis of the ocular muscles, and Graves's disease; while enlargement of the ball is the result of various conditions residing within the globe—myopia, intraocular tumor, and staphyloma. If the cause is unilateral, the resulting condition is asymmetrical; and the two eyes may be compared by observing the relative positions of the apices of the corneæ with each other, and with the line of the brows.

The eyeball is apparently sunken in some cases of ptosis and in wasting of the orbital fat, and is diminished in size in high grades of hypermetropia and congenital failures of development. As Nettleship has pointed out, the amount of exposed sclera decides the apparent protrusion or recession of the eyeball.

Position of the Eyes.—Instead of presenting parallel visual axes, one eye may be deviated inward, outward, downward, or upward, constituting one of the various types of strabismus (see page 507), a condition which may or may not be associated with diplopia (page 510).

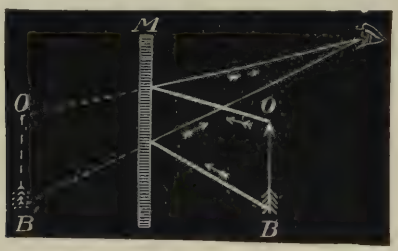
CHAPTER III.

REFLECTION. THE OPHTHALMOSCOPE AND ITS THEORY. OPHTHALMOSCOPY AND RETINOSCOPY.

Reflection.—When light falls upon a polished surface, a portion of it is reflected. The angle of reflection is always equal to the angle of incidence. A polished surface, capable of reflecting light, is called a *mirror*. Mirrors are either *plane*, *concave*, or *convex*.

A plane mirror reflects the rays falling upon it, so that they seem to come from a point as far back of the mirror as the object lies in front of it. It does not render the rays either convergent or divergent, nor does it lessen their convergence or divergence. Rays parallel before reflection are parallel after reflection. Rays convergent or divergent before reflection maintain the same relation after reflection. In the figure, rays from the object *O B*,

Fig. 43.



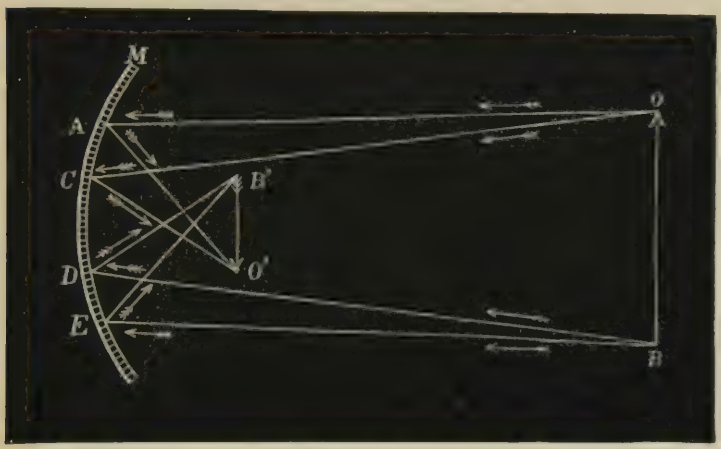
Reflection from a plane mirror.

falling upon the mirror *M*, are reflected so that they enter the observer's eye, and seem to him to come from *O′ B′*, situated as far back of the mirror as *O B* is in front of it. The image is not inverted. The rays have a divergence from a point whose distance is equal to the sum of the distance from the light to

the mirror, and of the distance from the mirror to the eye. (Compare Retinoscopy.)

A concave mirror converges parallel rays of light to its principal focus, and forms a real, inverted image in front of the mirror.

Fig. 44.



Reflection from a concave mirror.

The principal focus of a concave mirror is equal to one-half the length of its radius of curvature, $F = \frac{r}{2}$.

The conjugate focal distance for any point greater than the principal focus may be found by the following formula: f', represents the distance from which the rays diverge (the lamp or candle); f'' is the distance of the conjugate focus.

$$\frac{1}{f'} + \frac{1}{f''} = \frac{1}{F}.$$

$$\frac{1}{f''} = \frac{1}{F} - \frac{1}{f'}.$$

This is understood by recollecting that F is the focus for parallel rays, and that the focus is the inverse of the reflective or catoptric power of the mirror. The rays which diverge from f' require $\frac{1}{f'}$ of catoptric power to render them parallel. This diminishes the catoptric power of the mirror to $\frac{1}{f''}$.

$\frac{1}{F} - \frac{1}{f'} = \frac{1}{f'''}$, the focal length of f'', is the conjugate focal distance required.

Example: The ophthalmoscopic mirror has a focus of 20 cm., its radius of curvature being 40 cm. A candle is situated at 30 centimetres in front of it, and we wish to know the conjugate focal distance. $F = 20$ cm. $f' = 30$ cm. $\frac{1}{20} - \frac{1}{30} = \frac{1}{f'''}$ $\frac{1}{f''} = \frac{1}{20} - \frac{1}{30} = \frac{1}{60}$, $f'' = 60$ cm. The rays of the candle would be rendered convergent to a point 60 cm. in front of the mirror. The light being placed usually at a greater distance than the principal focus, the rays are always convergent.

A convex mirror renders parallel rays divergent as if they came from its principal focus, which is *negative*, situated behind the mirror, at a distance equal to one-half the radius of curvature. The image is erect and small.

The conjugate focal distances for convex mirrors are obtained by the same formula as for concave mirrors, the sign — being prefixed to F and f''.

The cornea, by reflecting light, corresponds to a convex mirror, and in this relation is important in ophthalmometry. The principal focus of the corneal mirror is about 4 mm., the radius of curvature being 7.829 mm. The size of the image reflected from the cornea is proportional to the size of the object, as the focus of the corneal mirror, 4 mm., is to the distance of the object. A candle flame 20 mm. in diameter, situated at 100 mm., gives a corneal image whose size is found in this manner: Image : 20 : : 4 : 100. $\frac{Image}{20} = \frac{4}{100}$. Image = .8 mm. If the radius of curvature is greater, the image is also greater; if the radius of curvature is smaller, the image is smaller. By this means, curvature ametropia may be measured.

The size of the corneal image is so very small that it would not be feasible to attempt direct measurement of it. If two candles, which are separated some distance, are employed as an object, each candle represents one extremity of the object. The size of the object is, then, the distance between the two candles; the size of the image is the distance between the reflected images of the candles. Suppose this distance to be 3 mm., and by means of a double refracting prism two images of each candle are seen;

if they are displaced by the prism exactly 3 mm., so that a straight line passes through all the images, two of them must overlie, as the images are 3 mm. apart. Small variations in curvature will now be manifest if the two images, which should overlie exactly, shoot past each other or fail to come together. The change of form in the crystalline lens during accommodation is proven by this experiment.

THE OPHTHALMOSCOPE.

Ordinarily the interior of the eye is not visible. The retina is not sufficiently illuminated through a small pupil to send back rays which are perceptible. At times with a dilated pupil a red glare may be caught from an eye in an ordinary light by an observer at some distance, but no satisfactory details can be made out.

In looking through the small aperture of the pupil, it is necessary for the observer to bring his eye close to the observed eye in order to discern the details of the eye-ground. In this position, no light can enter the patient's eye, because the observer's head intercepts it. If, now, a mirror be placed in front of the patient's eye, it will reflect the rays of a candle or lamp placed to the side of the patient and somewhat back of him, as if they came from in front of him. They will now enter the pupil and illuminate the interior of the eye. They are then reflected back from the retina and enter the eye of the observer. This is what the ophthalmoscope accomplishes.

In its most simple form (Helmholtz), it consists of three pieces of ordinary glass, set in a little frame. The amount of light reflected from one surface being about $\frac{1}{25}$ of the amount which falls on it, a combination of three surfaces is employed to increase the reflection. With this instrument the interior of the eye can be seen, but the illumination is weak, and the instrument has been superseded by a concave silvered mirror, which by converging the rays increases the illumination. The credit of the invention of this instrument is usually given to Helmholtz; but, according to Brudenell Carter, the ophthalmoscope had been invented, four years before Helmholtz's instrument appeared, by

Mr. Charles Babbage. His instrument consisted of a concave perforated mirror adapted with lenses. Unfortunately, it had been entrusted to a practitioner who did not appreciate its value, and it remained unknown.

The modern ophthalmoscope consists essentially of a concave silvered mirror for illuminating the eye, and of lenses for measuring and modifying its refraction. The mirror is perforated, and for convenience swings to either side, so that the obliquely incident rays may be reflected into the eye, without having to tilt the body of the instrument, and thus narrow the aperture and render the lenses astigmatic. A plane mirror, which can be substituted for the concave mirror, is a valuable addition to the instrument. The body of the instrument contains a disc carrying a number of lenses, which can be rotated in front of the sight-hole. The disc is the invention of Recoss. Most ophthalmoscopes contain two discs, which can be used either singly or in combination. This arrangement affords a series of lenses from .50 D to 24 D concave, and from .50 D to 23 D convex. The refractive errors of the eye are neutralized by these lenses, and thus the observer is enabled to view distinctly the details of the eye-ground in all forms of ametropia. A lens varying from 13 dioptres to 20 dioptres accompanies the instrument for obtaining focal illumination of the cornea and lens, as well as for the production of the image in the indirect method of ophthalmoscopy.

Direct Method.—The rays from the concave mirror, somewhat converging, enter the pupil and are brought to a focus in the vitreous humor. After reaching their focus the rays diverge again and spread out on the retina into a circle of diffusion. The portion of the retina thus illuminated sends rays back again, which pass through the dioptric media of the eye and are refracted to its far point; that is, if the eye is emmetropic, they emerge parallel and would meet at an infinite distance; if the eye is myopic, they converge to their far point in front of the eye. If the eye is hypermetropic, they diverge from their far point back of the eye.

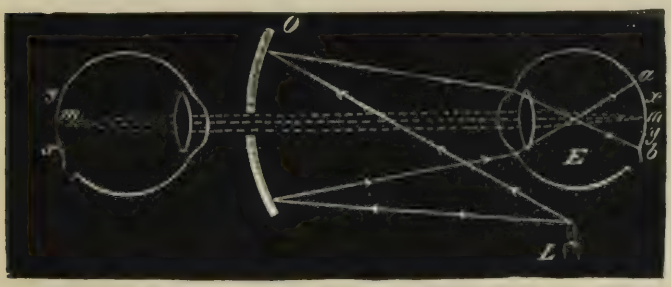
An observer's eye, in order to focus these rays, must be adapted to them. If the patient is emmetropic, the observer's eye must also be rendered emmetropic. If the patient is hypermetropic, the

observer must add a convex glass to his eye, or use his accommodation, in order to make the divergent rays parallel. If the patient's eye is myopic, the emmetropic observer must place a concave glass before his eye to render the convergent rays parallel. A hypermetropic observer might see distinctly the eye of a myopic patient, or a myopic observer might see the eye of a hypermetrope. In either case the hypermetropia must be somewhat greater than the myopia.

In this method the observer sees the eye just as he would see an object through a convex glass, or simple microscope. The image of the eye-ground is a virtual one; that is, it seems to be behind the eye. It is magnified and erect.

The formation of the image in the *direct method* may be understood by the figure.

Fig. 45.



Formation of the image in the direct method of ophthalmoscopy.

From the candle L the divergent rays falling on the mirror O are rendered convergent. Passing through the refractive media of the eye they are rendered still more convergent, and come to a focus in the vitreous humor; diverging again they form on the retina the illuminated circle whose diameter is $a\ b$. If this eye is emmetropic, rays from the points x and y will pass out of the eye into the eye of the observer. All the rays from the point x will be parallel. Rays from the point y will also be parallel. No image is formed; but the rays continue their course, and, entering the eye of the observer, come to a focus on his retina at the points x' and y'. Rays from the point x in the patient's eye unite at the point x' on the observer's retina. In a similar manner rays from the point y in the patient's eye unite at the point y' in the observer's eye. These rays, projected backwards, seem to lie in their true position.

Rays from the middle point *m* of the patient's eye unite on the middle point *m* of the observer's eye, and are projected backwards to the point from which they originated. The point *x*, above *m* in the patient's eye, is represented by *x* in the observer's eye below the middle point *m*. The point *y* below *m*, in the patient's eye, is represented by *y* above *m* in the observer's eye.

In hypermetropia, rays from *x* and *y* would be divergent, and the observer would have to render these rays parallel by a convex glass, or by using his accommodation. In myopia these rays would be convergent, and a concave glass would be required to neutralize their convergence and render them parallel.

It is necessary here to point out an important fact in relation to the formation of an image. Divergent rays and convergent rays have been described, but always in relation to one point. It is now necessary to consider their meaning in reference to an image.

An image is composed of a succession of points; each one of these points represents a point in the object. From the point in the object one ray passes to the optical centre of the lens, or lenses, and maintains the same direction after passing through it. This ray is called the *axial ray;* it passes to the corresponding point in the image.

Other rays from the same point in the object diverge from the axial ray at various angles; a bundle of these rays is called a *pencil.* The size of a pencil is determined by the diameter of a lens or the aperture of the pupil. The lens gives these unequally diverging rays a direction to a common point or focus. From each point in the illuminated part of the retina a pencil of rays falls upon the crystalline lens and cornea. The size of this pencil equals the diameter of the pupil; to form an image each pencil of rays must be concentrated into one point. By diverging and converging rays we mean the relation the rays from each point bear to each other, not the relation of rays from different points.

In the direct method the observer should place his eye close to that of the patient; otherwise only a very small portion of the fundus is visible. As the head is moved towards the right, additional portions of the retina towards the left are brought into view. If the head is moved towards the left, the portions of the eye-ground towards the right become visible.

Size of the Image.—The details of the eye-ground are considerably magnified in the direct method of examination. The optic disc, which measures about 1.5 mm., appears under this method nearly the size of a 25-cent piece. This, however, is only relative to the distance it is projected.

In the emmetropic eye the enlargement is found by the following formula: The distance of the retina from the nodal point (optical centre) of the eye is 15 mm. The observer projects the image which he sees to the point at which small objects are usually held, say 250 mm. The enlargement of the disc is proportional to these two distances, 15 : 250 : : 1.5 mm. : 25 mm. 16.6 = the enlargement. It is comparable to looking at the disc through a lens of 15 mm. focus, 66 dioptres.

It is to be remembered that the farther this image is projected, the larger it appears. In hypermetropia the enlargement is less than this. In myopia, on the contrary, it is greater.[1]

Indirect Method.—In the indirect method of ophthalmoscopy a real, inverted image of the interior of the eye is obtained by means of a strong convex lens (object lens).

This method is similar in principle to that of the compound microscope. The observer holds the object lens (a convex lens of about 20 dioptres) close to the patient's eye, and, placing a convex lens of 5 dioptres (eye-piece) behind the ophthalmoscope, throws the light into the pupil and moves his eye nearer to or farther from the patient's eye until he distinctly sees a vessel or a portion of the nerve. A real image of the eye-ground is formed by the object-lens at its focal distance in front of the eye. The observer sees this image, in which all the relations of objects are reversed. His eye is at a distance from the image equal to the focus of the lens in the ophthalmoscope, viz., 20 cm. The lenses of the eye and the convex lens form a combination like the objective of a microscope. The lens which the observer places behind the ophthalmoscope represents the eye-piece of the microscope.

The image being inverted, the lower portion of it corresponds to the upper part of the eye-ground. The right side of the image

[1] For the farther consideration of this, the student may consult Helmholtz, Physiolog. Optics, p. 216.

likewise corresponds to the left side of the eye. The upper and lower, as well as the right and left portions of the nerve, are reversed. The image also has a contrary motion. If the observer moves upwards, the image moves downwards; if the observer moves to the right, the image moves to the left. Consequently, the upper part of the image must be viewed if it is desired to see the lower part of the eye-ground, and the right side of the image if parts of the fundus to the left are to be examined.

Explanation of the image in the inverted method: It must be remembered that the observer sees the same portion of the eye-ground, when he moves his head to the right or left, in the direct method as he does in the indirect method. Starting in the *direct method* with the disc in view, the observer moves his head to the right. He thus brings into view a portion of the retina to the left of the disc. The disc now moves out of the field towards the right, and disappears behind the right edge of the pupil. The image, therefore, moves with the observer. In the indirect method with the image of the disc in view, if the observer also moves his head to the right, he sees the image of the same portion of the retina as in the direct method; but this being to the left of the disc, its image occupies a point to the right of that of the disc. (See Fig. 46.) The disc thus appears to have moved towards the left. The image, therefore, moves contrary to the observer's head. Movements in other directions are explained in the same way.

The nerve appears much smaller than it does in the direct method, but a larger portion of the eye-ground is visible at one time.

The *formation* of the *inverted image* in ophthalmoscopy is produced in the following manner:—

The ophthalmoscopic mirror *O* is held at a considerably greater distance from the patient than in the direct method. The rays from the candle come to a focus before reaching the eye, or object-lens. They then diverge, and, passing through the object-lens *l*, are rendered convergent. After traversing the dioptric media of the eye, their convergence is increased, and once more they unite somewhere in the vitreous humor, from which point they diverge and form a circle of illumination on the retina. Their course, in passing from the candle until they reach the retina, is shown by the arrow-heads in the figure.

A portion of the retina, a to b, represented by the arrow, forms an image, b' a', between the lens and the observer's eye, represented by the inverted arrow. Rays from the point a, on the upper part of the retina, pass out of the eye parallel to each other. After passing through the

Fig. 46.



Formation of the image in the indirect method of ophthalmoscopy.

object-lens l, they are rendered convergent and come to a focus at the point a' in the lower part of the inverted arrow. In the same way, rays from the point b on the lower part of the retina are parallel on passing out of the eye, but are rendered convergent by the lens l and come to a focus at a point b' in the upper part of the inverted arrow. It is this *aerial image* that the observer sees, and not the eye-ground of the patient. Rays from this image are focused on the observer's eye, just as rays from the retina were focused in the direct method, *i. e.*, the rays from the point a' are focused on a higher portion of the observer's retina, and rays from the point b' are focused on a lower portion. They are likewise projected back to the points in the image from which they originated.

It is evident that, as the observer moves downwards towards a', he sees the image of the upper portion of the retina a. As he moves upwards towards b', he sees the image of a lower portion of the retina in the direction b, since the highest portion of the retina forms the lowest portion of the image; and, as the observer looks towards the lower portion of the image, in reality he sees, in this image, a higher portion of the retina.

In hypermetropia and emmetropia a convex lens is necessary to render the rays convergent. In myopia the rays emerge convergent, and the convex lens may be dispensed with in the higher grades, though it is still an advantage because it increases the size of the image.

Size of the Image.—The enlargement of the image in this method is less than it is in the direct method.

A real image of the eye-ground is formed by the convex object-lens held at its own focal length from the eye. In this position the size of the image in an emmetropic eye is represented by the following proportion: The size of the disc is to the size of the image, as the distance from the retina to the nodal point (15 mm.) is to the focal length of the object-glass. If the lens has a focal length of 75 mm., the ratio is 15 : 75; the enlargement is then 5 diameters. A lens of 60 mm. focus would equal an enlargement of 4 diameters, 15 : 60.

The observer will see this image under a higher angle in proportion as he comes closer; it will then appear larger. To do this, he must either use his accommodation, or place a convex lens (eye-piece) behind the ophthalmoscope. When the eye-piece is used, a virtual image of the ærial image, still more enlarged, is produced, just as in the compound microscope. If the object-lens is withdrawn farther than its focal length from the observed eye, the image in myopia becomes larger, in hypermetropia smaller, and in emmetropia remains the same. If the lens is brought closer to the eye, the image becomes smaller in myopia and larger in hypermetropia.[1]

Ophthalmoscopy.—The investigation of the deeper structures and interior of the eye by means of the ophthalmoscope may, therefore, be practised with (1) the direct, and (2) the indirect method.

(1) The Direct Method (method of the erect or upright image).

The patient should be seated in a darkened room with his back to the source of illumination—an Argand burner being suitable—which is placed behind and to the side of his head, on a level with the ear, the face being in shadow, while the rays of light just fall upon the outer canthus of the eye. This will enable the observer to come quite close to the eye without interfering with the path of the illuminating beam. The surgeon

[1] The section on Reflection and the Ophthalmoscope and its Theory has been prepared by Dr. James Wallace.

sits at that side of the patient which corresponds to the eye under examination—for example, the right—his position being preferably on a slightly higher level than that of the subject. He now takes the ophthalmoscope in his right hand, looks through the sight-hole with his right eye, at a distance of about 50 cm. from the observed eye (the convex border of the instrument being in contact with the concave margin of his brow), meanwhile keeping the other eye open, and reflects the light into the right eye of the patient. If the left eye is to be examined, the ophthalmoscope is held in the left hand.

If the patient looks directly into the light thus transmitted, the pupil—provided this is not dilated with a mydriatic—will contract, and no view is possible. He must hence be directed to turn the head slightly to the right, and gaze into vacancy in the farthest limit of the room, when the pupil will be seen illuminated by a red glare—the reflection from the choroid coat—bright, if the pupil is large, and dull if it is small. No details of the fundus are as yet visible at this distance (50 cm.) unless a certain grade of myopia is present, or a considerable degree of hypermetropia. (See page 116.)

The beginner should now practise keeping the light steadily in position, and may estimate the success of his endeavor by observing the glare in the pupil. If this changes in color or disappears, the light has shifted from its proper position, because the examiner has failed to retain his elbow in close contact with his side, and allowed it to move outward and away from his body, the head meanwhile being bent to one or the other side of the vertical position it should assume in a direct line with that of the subject—feature to feature. This may be understood by observing the two accompanying illustrations. (See page 104.)

Having gained control of the light, the observer gradually approaches the eye of the patient, taking care that the red glare, which is tinted slightly yellow on the nasal side marking the position of the optic papilla, remains unaltered, and comes as close as possible—within one inch, or even nearer. If the manœuvre has been successful, and the light directed slightly towards the nasal side, the most prominent feature in the eye-ground—the optic nerve—will come into view; or a retinal vessel may

first be manifest, and should be followed to the papilla as a stream would be to its source.

Fig. 47.



Ophthalmoscopic examination. Method of the upright image. Observer and patient in the correct position.

Before proceeding to study the details of the fundus the student should make certain preliminary examinations.

a. The **Examination of the Cornea and Lens** is made by placing a + 7 D lens behind the mirror, and reflecting the light into the eye in the manner already described.

A foreign body on the cornea, a macula, a deposit on the posterior layer of the cornea, or an opacity in the lens appears as a black object against the red background, in contradistinction to its appearance in its true color under oblique illumination (page 62).

At the same time the mobility of the iris should be tested, and an observation made as to whether the iris reacts promptly and

evenly under the influence of the light directed into the pupil at various angles.

Fig. 48.



Ophthalmoscopic examination. Method of the upright image. Observer in an incorrect position.

b. The **Examination of the Vitreous** is made by reflecting the light from a distance of 30 cm. into the eye, while this is moved up and down, in and out.

Vitreous opacities and detached retina are seen in the erect position if the observer is sufficiently far away, because they are within his range of accommodation. If he approaches more closely, he must place behind the mirror a convex lens to bring them into focus.

c. The **Examination of the Transparent Media, with Reference to the Position of Opacities.**[1]—In order to detect the presence of dense opacities, the concave mirror of the ophthalmoscope may be utilized. Faint opacities are best discovered by means of the plane mirror. The eye under examination should be moved

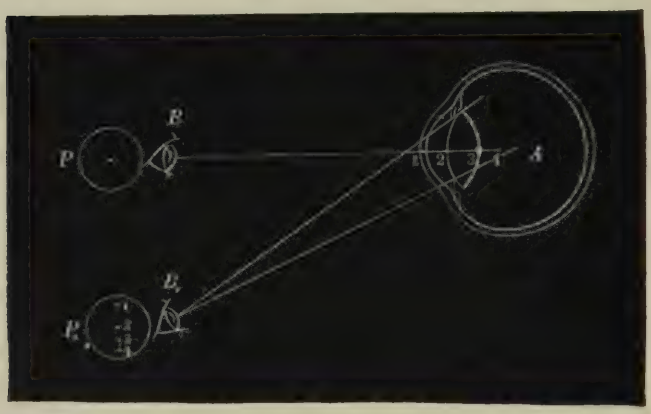
[1] This paragraph is based upon Fuchs's description.

in various directions, on the one hand, to bring into view opacities which have a lateral situation, and, on the other hand, to cause those opacities to rise upward which have sunk to the bottom of the vitreous chamber. Small opacities appear black ; larger opacities gray, or even white.

In order to ascertain the *position* of an opacity, it is necessary to determine whether it is freely movable or fixed. In the first case, the opacity must be in the vitreous. In the latter case, if the opacity moves only with the movement of the eye, but not in a self-dependent manner, it probably is situated in the cornea or in the lens, but may be present in the vitreous in the form of a fixed opacity.

In many instances the differential diagnosis can be made by means of oblique illumination. If this is not sufficient, the situation of an opacity is ascertained by means of its *parallactic* movement in relation to the border of the pupil. This can be understood by a reference to the figure.

Fig. 49.



Diagnosis of the situation of an opacity by the parallactic movement. (Fuchs.)

In the eye *A* there are four opaque points which lie in different layers : (1) In the cornea ; (2) in the anterior capsule of the lens ; (3) at the posterior pole of the lens ; and (4) in the anterior layer of the vitreous. For the sake of simplicity, these are supposed to be situated in the optic axis of the eye. If the observer *B* looks directly forward into the eye, he will see these four points in the centre of the

pupil P. If, now, the observing eye is moved from B to B_1, then the relative position of the points to the pupil will alter. Point 1 moves to the upper border of the pupil P_1; point 2 retains unaltered its real position in the pupil; points 3 and 4 approach the lower border of the pupil, 4 more than 3, corresponding to a deeper position.

From this example the following rule may be deduced in order to find out the position of an opacity: The observer looks directly forward into the eye, and notes the position of an opacity within the pupillary space. Thereupon, while the patient keeps his eye entirely quiet, the examiner slowly moves to the side and observes if the opacity retains, or does not retain, the same position in the pupillary space. In the first instance, the opacity lies in the pupillary plane, upon or immediately under the anterior capsule of the lens. In the second instance, it is situated in front of or behind this plane; in front of the plane if the opacity moves in a direction opposite to the movement of the observing eye, and behind the plane if the opacity moves in the same direction as the observing eye does. The quicker the change of position takes place, the farther is the opacity removed from the pupillary plane.

Instead of proceeding in this manner, the observer may retain his position unaltered, and cause the patient to move his eye in various directions (see page 105).

Having ascertained that the media are clear, and having approached sufficiently close, the details of the fundus oculi are brought into view and studied *seriatim*.

If either surgeon or patient is myopic, the necessary concave lens which corrects the error must first be placed in position; while, if hypermetropia exists, the fundus is visible without the aid of a glass, provided the hypermetropia is not in excess of the power of accommodation.

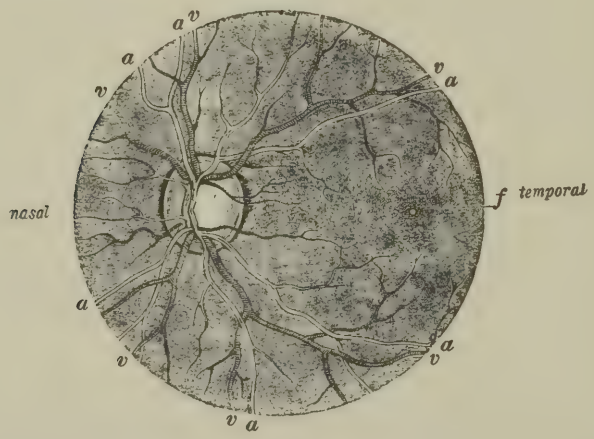
Failure to see any details, or seeing them as a blurred picture, naturally leads to the supposition that either myopia, or hypermetropia beyond the power of accommodation, is present. Beginners, however, often fail to obtain an image of sharp definition, owing to inability to relax accommodation, and succeed in seeing the details clearly only through a concave glass. The power of relaxing the accommodation comes with practice.

The **optic nerve** appears as a nearly round or slightly oval disc, situated towards the nasal side, varying in color from a grayish-pink to a more decided red, the tint being most marked upon the nasal half, while the centre is occupied by a whiter patch—the "light spot"—marking the position of the entrance and emer-

gence of the retinal vessels. The general tint of the optic disc varies with the age and complexion of the patient, and with the intensity of the color of the surrounding eye-ground.

The papilla is bounded by two rings. The outer one, dark-colored, usually incomplete, and sometimes entirely absent, or

Fig. 50.



Normal eye-ground of the left eye seen in the upright image. The vertically oval optic disc shows the entrance spot of the central vessels, somewhat to the inner side of its centre. The portion of the papilla which lies to the inner side of the vessel-entrance is more darkly colored than the outer half; the latter portion shows, stretching outward from the entrance of the vessels, a light-colored spot, the physiological excavation, at the bottom of which are seen fine gray stipplings, the spaces of the lamina cribrosa. The papilla is surrounded by a white ring, the scleral ring, encircling which in a more peripheral situation is an irregular, dark border, the choroidal ring, which, especially on the temporal side, is somewhat spread out. The central artery and the central vein divide out from the entrance spot in a superior and inferior branch, which appear somewhat lighter in this situation than in their further distribution in the retina, because they lie in the depth of the physiological excavation. The branches are still further divided on the papilla into a great number of twigs. Very fine twigs stretch from all sides towards the macula lutea, which itself is devoid of vessels, is somewhat more darkly colored, and in the middle of this a bright reflex, *f*, is visible. (Figure and description from Fuchs.)

existing only as a slight crescent of pigment upon one or the other side, is the "*choroidal ring*," and represents the border of the choroid coat where this is pierced by the optic nerve. Within this is a faint white stripe, more distinct in elderly people, and

when unusually broadened of pathological significance, the "*scleral ring*," which indicates the rim of the sclerotic coat.

The central white patch may be noticeable only by contrasting it with the color of its surroundings, or it may be a distinct excavation, occupying the centre of the disc, and having sharp borders, one of which often shelves slightly outward. This is the "*physiological cup*," and is the space left by the radiation of the nerve-fibres toward the retina, having a floor of white color, because it is composed of the interlacing opaque fibrous tissue, or *lamina cribrosa*, which underlies the optic papilla. It is often stippled in appearance, owing to the lack of light reflected by the non-medullated nerve-fibres which pass through the spaces of the lamina. According to Schoen, the so-called physiological excavations are due to dragging of the vaginal processes of the optic nerve and lamina cribrosa from over-exertion of the accommodation, and hence are found in adult eyes more commonly than in the eyes of children. They are practically always bilateral, although one may be larger than the other. Schweigger has traced hereditary transmission in some instances of large physiological excavation, but doubts if they are associated with any particular refractive condition of the eye.

The Bloodvessels.—From this central spot the *principal retinal arteries* emerge, and into it the *chief venous trunks* empty. Usually one venous and one arterial stem pass directly upward and downward, and on the edge of the disc, or a short distance from it, each divides into two branches. Sometimes this division has taken place in the axis of the nerve behind the lamina, and two arteries and two veins appear directly in the central opening of the papilla, or *porus opticus*. The arteries traverse the surface of the eye-ground, dividing dichotomously into numerous branches, and, passing above and below, spread in greater size and number over the temporal half of the retina, sending small branches toward the macula ; and in smaller size and less number over the nasal side. Fine branches arising from the central large trunks, or springing directly from the nerve, pass outward and inward, and also undergo numerous divisions.

The veins pass over the eye-ground in the same general direc-

tion as the arteries, and in close relation to them, emptying usually by means of two large branches into the centre of the disc.

According to the situation of the vessels, they are named, respectively, upper and lower temporal artery and vein, upper and lower nasal artery and vein, and macular and nasal arteries and veins.

The veins are dark-red in color, contrasting with the bright, natural blood-red color of the arteries. They are slightly tortuous, and larger than the arteries in the proportion of 3 to 2. The difference in color between veins and arteries is most marked in the major branches. In the finer twigs, after four or five divisions, the distinction between arteries and veins is often only possible by tracing them to their source.

Each vessel usually presents a double contour, owing to a bright stripe which passes along the centre, leaving a red line on either side. This so-called "*light reflex*" is a condensation by the refractive action of the blood column of the rays of light which have passed through the vessel from in front, and have been reflected back slightly from the posterior wall, but chiefly from the underlying tissues.[1] It is more marked upon the arteries than upon the veins, and, indeed, is often absent as the latter cross the disc, being visible in a minor degree when they lie at some distance in the retina.

Pulsation does not occur in the retinal arteries of the normal eye.[2]

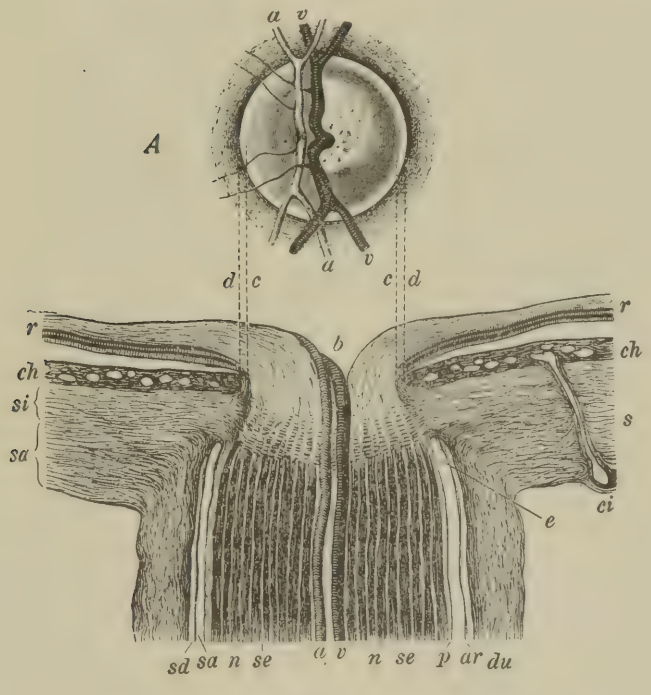
Spontaneous pulsation in the veins is a frequent phenomenon. Lang and Barrett examined 61 eyes between the ages of 11 and 65, and found marked venous pulse 45 times, or in 73.8

[1] The cause of the light streak has stimulated much discussion, and was usually attributed to reflection from the anterior surface of the vessel wall, or the anterior surface of the blood column, until Loring's investigation showed that the *refraction of light* was the chief cause of the phenomenon. Loring's conclusions have received very strong experimental confirmation in the interesting research of Achilles E. Davis. (Archiv. of Oph., vol. xx., No. 1.)

[2] This statement is practically correct, although the phenomenon of arterial pulsation has been noted in perfectly normal individuals by Graefe, Jäger, Donders, Becker, and Helfrich.

per cent. of the cases. It may be produced by a slight pressure upon the globe. The spontaneous pulse is due to a communication of the arterial pulsation to the vein, as these vessels lie side by side in the optic nerve, or may be explained by the theory of Donders, which stated that during the systole of the heart (diastole of the retinal arteries), an increased tension in the vitreous was communicated to the walls of the retinal veins, especially the

Fig. 51.



A, ophthalmoscopic picture of the nerve-head. *B*, longitudinal section of the nerve-head. (Figure and description (page 112) from Fuchs.)

larger ones, at their exit from the eye where the least resistance was offered, obstructing the flow of blood and compressing their lumen. The blood coming from the capillaries overcame this resistance, and the vessels regained their calibre, there being thus produced alternate collapse and distention.

The student will more readily understand the relation of the structures which have been described by examining Fig. 51, which should also be studied in connection with the paragraphs which follow.

The upper figure, marked *A* in the illustration, represents the ophthalmoscopic picture of the nerve-head. Slightly to the inner side of the centre of the papilla the *central artery* (*a*) is seen arising, and to the temporal side of this the *central vein* enters (*v*). To the outer or temporal side of the vein there is a *physiological cup*, at the bottom of which the gray stippling of the *lamina cribrosa* is visible.

The nerve-head is surrounded by the white *scleral ring*—between c and *d*—and the dark *choroid ring*, at *d*.

The lower figure, marked *B* in the illustration, represents a vertical section through the nerve-head; the trunk of the nerve as far as the lamina cribrosa has been colored dark by Weigert's method, and represents the medullated nerve-fibres (*n*). Between these the white spaces indicate the connective tissue septa (*se*). The nerve-trunk is inclosed in the pial sheath (*p*), the arachnoid sheath (*ar*), and the dural sheath (*du*). Between the sheaths the intravaginal space remains free; this arises from the subdural space (*sd*) and the subarachnoid space (*si*), both of which end in a blind cul-de-sac in the sclera (*s*) at (*e*). The dural sheath terminates in the outer layers of the sclera (*sa*), the pial sheath in the inner layers (*si*), which run crosswise through the optic nerve forming the lamina cribrosa. The nerve in advance of the lamina is colored light, because in this situation the nerve-fibres are non-medullated, and hence transparent.

The optic nerve spreads out into the retina *r*, and therefore in its middle there results a funnel-shaped depression—the vessel infundibulum—on the inner wall of which the central artery *a*, and the central vein *v*, rise upward. The choroid (*ch*) shows the cross-section of its numerous vessels, and towards the retina a dark border—the pigment epithelium. Next to the border of the optic nerve entrance the choroid is more darkly pigmented and corresponds to the choroid ring. At *cc* a short posterior ciliary is shown passing through the sclera to the choroid. Between the border of the choroid *d*, and the border of the nerve-head c, a small interspace remains, in which the sclera is evident, and corresponds to the scleral ring visible in ophthalmoscopic examination.

Physiological Variations.—The papilla, instead of being round, or slightly oval with a vertical long axis, is often distinctly irregular in outline, or has its long axis in the horizontal direction.

The physiological cup varies in shape, area, and depth. Nor-

mally situated on the temporal side, it may be a deep pit, funnel-shaped, with overhanging margins over which the vessels sharply bend, or very shallow and dish-like, sloping to the temporal side, or deep and sharply marked on its inner side, but shading outward.

The usual distribution of the vessels is subject to numerous variations, so much so that it would be difficult to find it the same in any two eyes. The usual departure from the ordinary type is the one already referred to, in which four major branches (two arteries and two veins) appear at the centre of the porus, instead of two large branches which later divide at or near the margin of the disc. Anomalies of the veins upon the disc, in the form of unusual bifurcations, are occasionally seen. Divisions of the vein just before entering the disc; division at the margin; the formation of a vascular circle and final reunion in a single vessel; and anastomosis of the central vein with an aberrant vein, or one which has penetrated the inner side of the disc, have been described (Randall). The veins are normally more tortuous than the arteries. Both sets of vessels present this appearance in marked degree as symptoms in certain pathological conditions, but also occasionally as an anomaly without such significance (Nettleship). Again, the vessels may stand forward from the disc in a high curve, or twine around each other, as we sometimes see two stems on a vine.

An anomaly of not infrequent occurrence is the presence of a *cilio-retinal vessel;* that is, one which passes into the margin of the disc at or near to it, then arches outward or away from the disc before it finally disappears in its passage toward the macula, to which it is usually destined. In a series of examinations, Lang and Barrett found this condition present in 16.7 per cent., doubtful in 6.3, and absent in 77 per cent.

In addition to the variations just described, numerous anomalies are found, to which reference will be made in the sections devoted to the descriptions of the diseases of the retina and optic nerve.

The Retina.—Inasmuch as the retina is practically transparent, a study of this membrane is hardly possible without a consideration of the underlying choroid and even the sclera.

In certain persons, especially of dark complexion, the retina

assumes a grayish tint in the neighborhood of the papilla, most marked upon its nasal half. This faint opacity is slightly streaked, the striations indirectly corresponding to the expansion of the optic nerve fibres. Eyes long subjected to the strain of uncorrected ametropia furnish an exaggerated picture of this appearance, which, if at all extensive and associated with similar opacities along the lines of the vessels, assumes pathological importance (see Retinitis).

In the eyeground of young subjects, particularly along the line of the vessels, numerous wave-like glistening reflexes may be seen to follow one after another with the slightest movements of the ophthalmoscopic mirror. The effect is similar to the shimmer seen on the surface of certain silks, and has been designated by English writers "shot-silk retina." It is unusual to find the phenomenon in individuals over thirty, its occurrence being marked in direct proportion to the youth of the subject.

Macula Lutea.—About two discs' diameter to the outer side of the papilla and slightly below the horizontal meridian, there is a spot, equal in area to the end of the optic nerve, darker in color and more granular than the surrounding fundus, uncrossed by any visible retinal vessel, but toward which the finer twigs of the major branches radiate, fringing its boundary. This region is the *macula lutea*, or yellow spot, and is that portion of the eyeground concerned with functions of direct vision.

Its centre is occupied by a small bright dot, or the *fovea centralis*, which is surrounded by a dark area, sometimes containing a few black and light-colored granules, in its turn bounded by a *whitish ring* or *halo*. In the place of the bright dot, occasionally a shifting crescent or small circle may be seen.

These characteristics of the macula are by no means constant, and are seen only or most notably in young children. In elderly people, the region cannot be recognized except by the absence of vessels, and the darker color of the underlying choroid. In blondes and albinos it is still more difficult to define this area.

Although no vessels visible to the ophthalmoscope cross the macula, except as an anomaly (Randall), the region is abundantly supplied with capillaries, as Mr. Nettleship has shown by artificial injection, which surround the fovea in a close loop, but do not

occupy it. The student will find the macular region difficult of recognition, not only because its characters are often ill-defined, but because the light falling upon it causes the pupil to contract, the view being further hindered by the corneal reflex. If the pupil is dilated by a mydriatic, the macula comes into view by requiring the patient to look directly into the ophthalmoscopic mirror. If not, it must be found by turning the light outward from the lower edge of the disc.

The appearances in the macula depend upon the imperfect development of some of the layers of the retina, while in the centre or fovea practically only the cones and outer granules remain. On the other hand, the layer of ganglion cells is more fully developed than in the surrounding retina, giving the impression of increased thickness in this area. The fovea, being a depression, appears to the ophthalmoscope as a light spot due to the reflex from its edges or walls, while the halo, or ring encircling the macula, arises in consequence of the thickening of the tissues. The more decided pigmentation in the epithelium produces the darker color, which distinguishes it from the neighboring fundus.

The Choroid.—The bright glare which illuminates the pupil when the light is thrown into it from the ophthalmoscopic mirror, and develops into the uniform red color of the fundus, when this is brought into view, arises from the choroid. The rays of light pass through the transparent retina to its pigment epithelium, which in ophthalmoscopic work is accredited to the choroid (see Fig. 51 B, *ch*), and in part are absorbed and in part reflected. The greater the quantity of the pigment, the greater the amount of absorption, so that the color of the eye-ground depends upon the degree of saturation in this epithelium, and varies from an almost slaty color in the dark-skinned races to a fiery red in persons of blonde complexion.

In very fair people, the imperfect development of pigment-cells of the choroid exposes the larger choroidal vessels, which are evident as a mesh-work of tortuous red bands with intervening spaces of lighter or darker color, and which are distinguishable from the retinal arteries and veins by their flat appearance and absence of the light streak. The most perfect exposure of the choroidal

vessels is seen in albinos. It is not usually possible with the ophthalmoscope to differentiate the arteries and veins of this system, although the latter are of greater size, and, near the equator of the eye, converge toward the venæ vorticosæ, being separated by larger and longer spaces. In decided brunettes, these spaces are more deeply tinted than the vessels which appear "like light streams separated by dark islands" (Nettleship). A fair general idea of what tint may be expected in the fundus may be obtained by observing the color of the patient's hair.

All of the details of the eye-ground may be studied with greater ease through a dilated pupil, and on beginning his studies the student may with propriety employ a mydriatic, cocaine, or homatropine, not atropine, provided no signs of glaucoma are present. Having acquired knowledge of the normal appearance thus seen, he must now practise with the undilated pupil.

The disc and macula having been studied, the peripheral parts of the eye-ground should be examined by throwing the light inward, upward, and downward, the head of the observer being moved correspondingly to comply with the changed direction of the mirror. Even when the central part of the fundus presents the usual characteristic red tint, the choroidal vessels are frequently exposed in the periphery presenting the appearance just described, and having no pathological significance.

Determination of Refraction by the Ophthalmoscope.—The estimation of the refraction of the eye by means of the ophthalmoscope results in either a *qualitative* or *quantitative* determination.

The former is obtained in the following manner: Hold the ophthalmoscope 30 to 50 cm. from the patient's eye, and looking through the central aperture of the mirror, unaided by a glass, observe if any vessels come into view. Their appearance means that the eye is either hypermetropic or myopic. Now move the head from side to side, and note if the vessels move apparently in the same or in a direction opposite to the movements of the head. If the former, the eye is hypermetropic; if the latter, myopic. Inasmuch as the image of the vessels in low degrees of myopia would be formed only at a considerable distance from the observed eye (30 to 120 cm.), and since no sharp image would

be obtained in either emmetropia or low degrees of hypermetropia farther away than 30 cm., any considerable degree of ametropia may be excluded by failure to obtain a direct image except at a long range or a very short distance from the patient's eye.

Before attempting a *quantitative* estimation of the refraction by means of the ophthalmoscope, certain fundamental rules must be observed :—

1. *Both surgeon and patient must have relaxed accommodation.* The ability to relax the accommodation comes with practice, and is best secured for the patient by requiring him to gaze inattentively into the farthest corner of the well-darkened room.[1]

2. *A certain definite spot in the eye-ground upon which to focus should be selected.*

Naturally the macula, or region of accurate sight, would seem to offer the most desirable point; but, owing to its ill-defined characters, and the difficulty of making accurate observation through the undilated pupil, which contracts when the light falls upon this region, and the dazzling corneal reflex, it does not serve a satisfactory purpose; hence, it is better to select the edge of the optic disc, or the medium-sized vessels midway between the disc and the macula, where two branches, running at right angles to each other, may readily be found.

[1] Loring (Text-Book of Ophthalmology, vol. i, p. 107), speaking of the necessity of practice in order to secure the ability to relax the accommodation, has suggested the following method: "If the observer is emmetropic, one of the best methods of acquiring this control over the accommodation is to take a convex glass of moderate power, say 3 D, and ascertain the farthest point at which fine type can be read with perfect distinctness through the glass, the other eye being closed, or, better still, opened but excluded from the visual act by a screen. Under this condition there is a tendency for the visual axes to assume a parallel position, and with it that perfect state of rest usual to the eye when looking at the most distant objects. If the object can be moved in this case to a distance of 12 inches, it is proof positive that the accommodation is entirely relaxed, since, as the object viewed is situated at the principal focus of the glass, only parallel rays can enter the eye, and such rays can only be brought to a focus on the retina of an emmetropic eye when it is in a state of perfect rest. The experiment should be repeated with glasses of varying strengths till the ability is acquired of always seeing the test object at the focal distance of the glass used. This once acquired, a little further practice with the ophthalmoscope will also enable the observer to relax his accommodation during the examination."

3. *The observer should approach as close as possible to the eye under observation.*

If he is able to place with the ophthalmoscope a correcting lens at a point 13 millimeters in front of the cornea, he has reached the anterior focal point of the eye, and the power of such lens would express the degree of ametropia, and be equivalent to one set in a frame which had been found by the usual tests to neutralize the refraction error. If he is unable to reach this point, and holds the ophthalmoscope with the correcting lens at a point farther away from the cornea than 13 millimeters, the distance between the glass and the cornea must be subtracted from the focal distance of the correcting lens, in order to ascertain the real amount of hypermetropia, and be added to the focal distance, to obtain the degree of myopia.

If the observer employs lenses ground according to the old system of notation, in which the number of the glass expresses its focal length, the following rule, taken from Loring, serves to determine the condition of refraction: "The ametropia in a given case is equal to the glass used plus the distance between it and the nodal point if the eye examined be myopic, minus the distance, if it be hypermetropic."

4. *In order to ascertain correctly the refraction error, the observer must be emmetropic, or if not, render his eye emmetropic by using the proper correcting lens, either in the form of spectacles or an equivalent glass placed behind the sight-hole of the ophthalmoscope.*

The emmetropic observer can see the details of the myopic eye-ground only dimly without the aid of a correcting glass, and not at all if the myopia is of high degree. By placing concave glasses behind the sight-hole of the ophthalmoscope, the convergent rays which leave the observed eye are rendered less and less convergent until that glass is reached which just yields a distinct image, *i. e.*, one which has rendered the convergent rays parallel.

The emmetropic observer can see the details of a hypermetropic eye-ground distinctly without the aid of a correcting glass, unless the hypermetropia is of very high degree, by an effort of accommodation which renders his crystalline lens more convex, and thus causes the divergent rays which leave a hypermetropic eye to

become parallel. But, with accommodation relaxed, he sees distinctly the details of the fundus through a convex lens placed behind the ophthalmoscope; this should be substituted for other stronger convex lenses until the strongest one is reached with which a clear image is still possible, *i. e.*, one which has rendered the divergent rays parallel, while the next highest number creates a blur over the details of the eye-ground.

From what has been said it follows: The strongest convex lens, placed in position in the ophthalmoscope, with which the emmetropic observer can still see the details of the fundus at the point selected, measures the degree of hypermetropia; the weakest concave lens, the degree of myopia. The hypermetropia usually is somewhat greater, and the myopia somewhat less, than the result obtained by ophthalmoscopic examination.

In order to estimate the refraction of the eye examined, the hypermetropic observer must subtract from the convex, or add to the concave lens, which yields him a sharp image of the fundus, the amount of his own error, while the myopic observer must add to the convex, or subtract from the concave lens, with which he sees by the eye-ground the degree of his own near-sightedness.

In order to calculate the amount of lengthening or shortening of the eye equal to a lens which neutralizes the myopia or hypermetropia in any given case, and provided the distance between the surgeon's eye and that of the patient is not more than 2.5 cm., the following table, which is taken from Nettleship, and which he has altered from Knapp, is useful:—

H. of	1	D	represents	a	shortening	of	0.3	mm.
"	2	"	"	"			0.5	"
"	3	"	"	"			1	"
"	5	"	"	"			1.5	"
"	6	"	"	"			2	"
"	9	"	"	"			3	"
"	12	"	"	"			4	"
"	18	"	"	"			6	"
M. of	1	D	represents	a	lengthening	of	0.3	mm.
"	2	"	"	"			0.5	"
"	3	"	"	"			0.9	"
"	5	"	"	"			1.3	"
"	6	"	"	"			1.75	"
"	9	"	"	"			2.6	"
"	12	"	"	"			3.5	"
"	18	"	"	"			5	"

By this table the depth of an excavation in the papilla may be measured. For instance, if the bottom of the pit required — 5 D for its sharp examination, and the margin of the nerve was seen without any glass, the depth of the excavation would be 1.3 mm.

The presence of *astigmatism* may be ascertained by means of the ophthalmoscope and the upright image, and, in skilled hands, its amount measured with reasonable accuracy.

In all such examinations the instrument must be close to the eye and in an exact perpendicular line, and the following points observed :—

(*a*) The optic disc is an ellipse, its long axis corresponding with the meridian of the greatest refraction, and its short axis with the meridian of least refraction. When the principal meridians are vertical and horizontal, the disc usually is a vertical oval, more rarely a horizontal oval.

When the principal meridians are inclined, they sometimes correspond to the direction of the long and short axes of the ellipse assumed by the nerve-head. As, however, the disc is often oval in non-astigmatic eyes, this evidence is not satisfactory.

(*b*) All points of the portion of the fundus under examination are not in focus at the same time, *e. g.*, the retinal vessels running in the directions which correspond to the principal meridians.

Thus, when two vessels cross each other at right angles, the vertical branch may be sharply seen, while the horizontal one presents a blurred image, or the upper and lower margins of the disc may be clear, but the lateral borders indistinct. The amount of hypermetropia, or of myopia, of the *vertical* meridian is equal to the strongest convex, or weakest concave, glass which makes distinct the vessels running in a *horizontal* direction. The refraction of the *horizontal* meridian is determined by the glass which yields a clear image of the vessels running in a *vertical* direction. As the vessels do not correspond to the layer of the rods and cones, the measurement is an approximation.

If a vertical vessel is sharply seen with a convex lens of 3 D, while the vessels at right angles to it are clearly visible without the aid of any glass, and blurred by the addition of a convex one, hypermetropia of 3 D exists in the horizontal meridian,

because a line, in this case a vessel, appears most distinct in the meridian of greatest ametropia, inasmuch as it is seen by means of the rays passing through that meridian of the cornea which lies at right angles to its course (see page 168). If, in another eye, the vertical vessels appear distinct without the aid of a glass, and the horizontal vessels require a concave lens of 3 D to bring them into focus, myopia of 3 D exists in the vertical meridian. In the one instance, there is *simple hypermetropic astigmatism* which would require a + 3 D cyl., axis vertical, for its neutralization; and in the other, a *simple myopic astigmatism* demanding a — 3 D cyl., axis horizontal, for its correction.

Compound astigmatism is determined by finding, in hypermetropia, the strongest convex lens which the vessels in each meridian will bear with the preservation of a distinct image, and subtracting the one from the other, thus finding the difference between the meridians, *i. e.*, the amount of astigmatism. Thus, if the vertical vessels remain in focus when viewed through a + 3 D lens, and the horizontal vessels through a + 1 D, there is a general hypermetropia of 1 D, with a difference of 2 D, between the principal meridians. This difference of 2 D represents the amount of the astigmatism. In the same way, myopia of varying amounts in each meridian is measured. The correcting glass in the first instance would be + 1 D sph. $\frown$ + 2 D cyl., axis vertical.

If the vertical vessels are distinctly seen with + 3 D, while the horizontal vessels require a — 1 D for their perfect detection, myopia of 1 D exists in the vertical meridian, and hypermetropia of 3 D in the horizontal meridian. There is an astigmatism in this case of 4 D. The principal meridians are respectively myopic and hypermetropic, constituting what is termed *mixed astigmatism.* (Compare page 166.)

The measurement of astigmatism in this manner, with any degree of accuracy, requires a vast amount of practice, a perfect control of the accommodation, and even then must never be employed to the exclusion of other and more trustworthy methods.

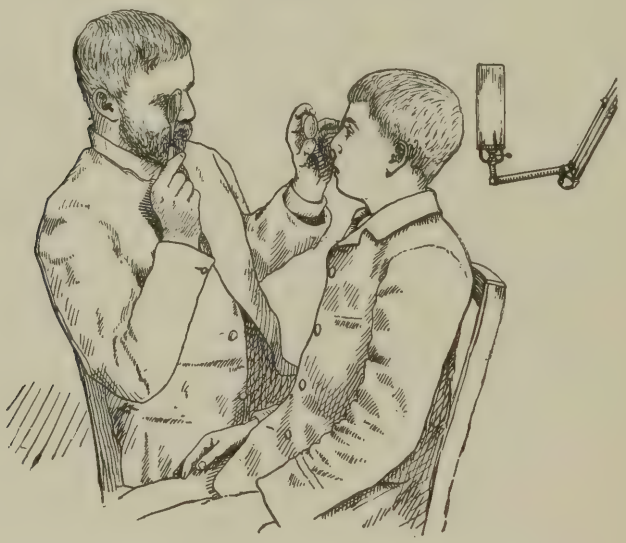
(2) The Indirect Method (method of the inverted image).

The patient and surgeon are seated in the same relative positions as have already been described in connection with the direct

method, and, if the right eye is to be examined, the ophthalmoscope is held in the right hand at a distance of 30 cm. from the patient, who is instructed to look at the right ear of the examiner. A convex lens of 20 D, held between the surgeon's left thumb and index finger, while the remaining fingers are rested upon the brow to steady the hand, is placed at about its own focal length in front of the patient's eye, directly in the path of the rays returning from the fundus, which are thus brought to a focus and form an aerial image between the observer and the glass.

If the left eye is to be examined, the ophthalmoscope is held in the left hand, and the patient instructed to look at the surgeon's left ear, while the lens, grasped in the fingers of the right hand in the manner just described, is placed in position.

Fig. 52.



Method of the indirect examination with the ophthalmoscope.

Much practice is required to gain perfect control of the illumination, and at the same time to keep the ophthalmoscope, lens, and patient's eye in proper relation. This is largely due to the difficulty of securing perfect accord between the relative positions of the two hands. While the beginner endeavors with one hand

to place the lens properly before the patient's eye, his attention for the moment is distracted from the other hand which holds the ophthalmoscope, and this becomes unsteady and permits the light to shift from the pupillary area.

This difficulty having been overcome, facility in using the supplementary lens, or, as it is often called, the object-glass, must be acquired, especially to avoid the confusing reflexes from its surfaces, and the magnified image of the iris. This is best accomplished by holding it in a slightly oblique direction, and at a point a little farther away from the cornea than its own focal length. The glass should now be moved up and down, back and forth, to obtain alterations in focus and displacements of the image from side to side, and a parallax between points situated at different levels in the eye-ground.

The image which is found at a certain distance in front of the object-glass may not present itself to the observer as a distinct picture, owing to his inability to accommodate for the point of its formation. This accommodative strain may be relieved, and the image magnified, by placing behind the ophthalmoscope a convex glass of 5 D which adapts the emmetropic observer, with relaxed accommodation, for a point 20 centimetres distant. If the observer is presbyopic, or has a deficient amplitude of accommodation, this additional lens is absolutely necessary; while, if he is hypermetropic, the degree of his hypermetropia should be added to the glass used as a magnifier. The observer possessing a moderate degree of myopia requires no lens in the ophthalmoscope, because he views the aerial image at his far point, while, if his myopia is of high grade, he will need a weak concave glass.

If, then, the examiner, having illuminated the pupil from a distance of 30–50 cm., finds the slightly yellowish area in the general red glare indicating the position of the optic papilla, and places the convex lens (object-glass) in position, and the second convex lens (eye-piece) behind the ophthalmoscope and secures an aerial image, he will observe the following characteristics in contrast with the appearances seen by the direct method; always remembering that the picture is inverted, and that what apparently is on the nasal or inner side really belongs to the outer or temporal side; that what apparently is below really is above:—

1. *The field is larger.*

Not merely the object, the optic nerve for example, comes into view, but also a portion of the surrounding eye-ground, precisely as a more extensive portion of the field of the microscope is obtained through an objective of low power than through one of high power.

2. *The individual objects in the field are smaller and more sharply defined, but the finer details are less perfectly revealed, because seen under a lower magnifying power.*

The relation between the extent of the fundus visible and the size of the details depends upon the strength of the supplementary convex lens (object-glass). If this is strong, the expanse of the field brought into view will be greater, while the component parts will be smaller (Loring). Hence, if it is desired to enlarge the image of the fundus at the expense of its extent seen at one time, instead of a 20 D convex glass, one of 10 D should be employed.

3. *The differentiation between objects of similar appearance, e. g., the vessels, is less perfect.*

Working under these conditions the student will observe that the optic papilla is smaller, its edges more sharply defined, and the faint veiling of the nasal margins caused by the striation of the surrounding retina less noticeable.

The difference between veins and arteries is not so marked as with the direct method, and it may be well-nigh impossible to distinguish from each other the finer twigs of each system. As a rule the veins, being larger and darker, present a more distinct image than the arteries, which are slightly blurred in outline. The light streak, so noticeable in the upright image, is frequently wanting.

The macular region, especially if the pupil is not dilated, presents unusual difficulties in its study. If the patient is required to look directly into the opththalmoscope, this illumination of the macula causes a contraction of the pupil (if the iris is not under the influence of a mydriatic), and brings into existence confusing reflections. It is best brought into view by first finding the papilla, and then moving the object-glass horizontally across the line of vision until its inner margin corresponds with the

outer border of the pupil. In young subjects the light reflex encircles an elliptical dark area containing in its centre a reddish, or, less frequently, a bright point surrounded by a small brilliant ring. These characteristics are almost invariably lacking in adults, and may not be present in children. Under these circumstances, the macula is distinguishable only by the ill-defined appearances of a darker tint and an absence of vessels.

Estimation of Refraction by the Indirect Method.—A *qualitative* estimation of the refraction may be ascertained with the mirror alone by observing if any portion of the fundus comes into view when this is held at a distance of 50 cm., and if this image, the observer's head being turned slightly from side to side, shifts apparently in the same or an opposite direction to the movements of the head. (p. 116.)

The measurement of the *degree* or *quantity* of the refraction by the indirect method is possible by attending to the following directions adopted by Koenigstein: Since the rays which proceed from an emmetropic eye are parallel, the image of its fundus appears at the focus of the convex lens (object-glass), while that of the hypermetropic eye is developed farther from, and that of the myopic eye nearer to, the lens. In order to ascertain the degree of ametropia this distance must be known and we proceed in the following manner:—

If the observer is not naturally myopic, he renders himself so by employing a convex lens behind the mirror, for example, 5 D, which puts him in the condition of a myope with a far point of 20 cm., *i. e.*, he cannot see distinctly beyond this point. If, now, the inverted image is developed through a lens of 10 D, held at its focal distance from the cornea, and the distance between the ophthalmoscope and the lens measured, the observer will also ascertain, if he does not accommodate, the distance of the image from the lens, and from this calculate the refraction, as may be understood from the following example: The inverted image is developed, the observer withdraws to the farthest point from which he can still see the image distinctly, and measures the distance between the ophthalmoscope and the lens, which he finds is 30 cm. It follows, as his far point lies at 20 cm. (he being artificially myopic in this degree), that the

image is 10 cm. from the lens, or at its focus; the rays have proceeded in a parallel direction from the observed eye, and this is emmetropic. If the distance between the ophthalmoscope and lens is greater, *e. g.*, 35 cm., then the image is 35–20 = 15 cm. distant from the lens and the refraction is hypermetropic, in this instance, 5 D. If the distance is shorter than 30 cm., *e. g.*, 25 cm., then the image is situated between the lens and its focus, and the refraction is myopic, also 10 D.

High grades of myopia may be calculated by a simple measurement of the distance. Rays proceed from a myopic eye convergent and form an inverted image at its far point, without the aid of an object-glass. The distance between the eye and the ophthalmoscope is taken, and from this is subtracted the far point of the observer. If, for example, an emmetrope with + 4 D observes the inverted image of the fundus distinctly, and the measurement between the observer and the observed eye yields 35 cm., the former having a far point of 25 cm., the image is 10 cm. distant from the observed eye, and the myopia 10 D.

For practical purposes, this method does not enjoy material advantages, and is open to the serious objection of inability to secure accurate measurements, especially in hypermetropia. Its field of usefulness is almost entirely limited to very high grades of myopia.

Estimation of Astigmatism by the Inverted Image.—The existence of astigmatism is determined with the indirect method by the changes which take place in the shape of the optic nerve, as the refractive condition of the eye varies in its different parts. In the direction of least refraction, the image of the nerve contracts as the lens is withdrawn; in the direction of greatest refraction, the image of the nerve expands; in the absence of astigmatism, the round or oval shape of the nerve is not altered whether the lens be held close to the eye, or removed from it. In direct ophthalmoscopy, the disc usually is a vertical oval when astigmatism exists; the same disc viewed by the indirect method, with the lens held close to the eye, is a horizontal oval, but as the lens is withdrawn farther from the eye, it becomes a vertical oval. This may be produced in different ways.

If the horizontal diameter is diminished by withdrawing the

lens, the astigmatism is *hypermetropic*, but if the vertical diameter is increased by removing the lens, the astigmatism is *myopic;* if both diameters are diminished, but one more than the other, the astigmatism is *compound hypermetropic;* if both diameters are increased, but one more than the other, the astigmatism is *compound myopic*. The most marked effect is produced in *mixed astigmatism*, where the myopic vertical meridian causes the disc to spread out vertically, while the hypermetropic horizontal meridian causes it to dwindle in the transverse direction. The disc then shoots out rapidly in the vertical direction, while in the horizontal direction it rapidly contracts.

Ophthalmometry.—This term indicates mensuration of the eye, and as usually employed is limited in its application to the measurement of the radius of curvature of the cornea. In order to practise ophthalmometry, instruments for taking the measurement of the radius of curvature of the cornea have been devised, and are known as *ophthalmometers*. The ophthalmometer most in use at the present day is the one devised by Javal and Schiötz.

The following description, modified from the one given by Dr. Noyes, gives the essential points of the instrument: There are two objects; the one fixed in position, bearing a white rectilinear figure; and the other one, sliding back and forth on the arc, is composed of white enameled blocks, each one of which is calculated to represent one dioptre of corneal refraction, or a power equal to a cylinder of one dioptre. The movable object and the stationary white rectilinear figure are placed so that their images will be reflected from the cornea. These reflections, which are viewed by a small telescope, are doubled by passing through a prism placed between two biconvex lenses, and having in addition a third biconvex lens which shortens the posterior foci of the two images, which foci are marked by a thread of spider's web. The patient's face is placed in the frame and is steadied by a chin and forehead rest. The telescope stands upon a tripod which can be moved forward and backward in order to obtain the proper focus. The central images are obtained sharply on the spider web, and the movable object passed along the arc of the instrument until it comes in contact with the rectilinear figure. This having been done, its position on the arc is read off upon an index. The

arc is then turned at right angles to this position, and the relation of the two images noted. If they have not changed either by overlapping or separating, the curve of the cornea is the same both horizontally and vertically. If the images overlap in the vertical meridian, the radius of the curve is longer in this meridian, and there is astigmatism. If the images separate with the bar vertical, this meridian has a shorter radius than the horizontal, and again there is astigmatism. Each enameled block, as before stated, has been calculated to express one dioptre of corneal refraction, and consequently the amount of astigmatism is read off.

In the opinion of many competent observers, this is the best objective test of astigmatism which we possess. A great disadvantage is the expensiveness of the instrument, and as yet it has not come into general use, although it is being used more and more for this purpose.

Optometry is a term which indicates the principles involved in the measurement of the refraction of an eye by its limits of distinct vision. The instrument which thus serves to determine the refraction of the eye is called an *optometer*.

Optometers are based upon a number of principles. For instance, a single convex lens by which the direction of the luminous rays emanating from an object is changed, and consequently the determination of the refraction of the eye rendered possible, constitutes an optometer. Other optometers are based upon the principle of a telescope; still others upon the measurement of circles of diffusion; upon Scheiner's experiment, and upon the chromatic aberration of the eye. It would not be possible, in the limits of this manual, to describe in detail the principles involved or the various forms of apparatus which have been employed. Should the student desire to pursue the subject, he may with advantage consult the chapter devoted to this method found in Landolt's Refraction and Accommodation of the Eye.

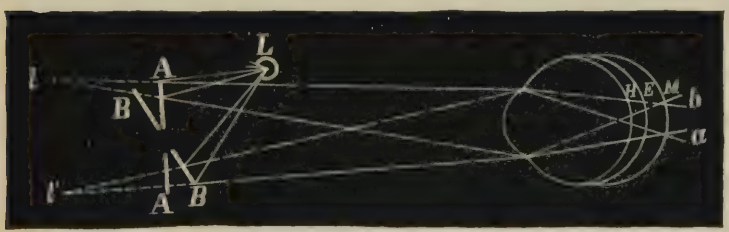
Retinoscopy[1] **[Skiascopy, or the Shadow Test]**.—This is a method of determining the refraction of the eye by observing the direction in which the light appears to move across the pupil, when the mirror by which light is thrown upon the eye in the dark room is rotated.

[1] The section on Retinoscopy has been prepared by Dr. Edward Jackson.

With the ophthalmoscope, as has already been explained, one may look into a myopic eye from close in front of it, and see an erect image of the fundus, which he can render clear by the proper concave lens; or, from a greater distance, he can view an inverted image of the fundus, with or without the intervention of a convex lens. The point at which the change from the erect to the inverted image occurs has been called the *point of reversal.* It is the point for which the eye is focused, and is the far point of distinct vision. Retinoscopy is simply an accurate method of determining this point of reversal.

To apply the test the surgeon faces the patient at a distance of about one metre, and, holding the mirror to his own eye, reflects on the patient's face the light from a lamp, placed between them and shaded from the patient's eyes, if the plane mirror is employed, or placed behind the patient if the concave mirror is used. By rotating the mirror the area of light it throws on the face is made to move up and down, or from side to side, or obliquely. The part of the light that falls on the patient's pupil is condensed on his retina, forming there a small light area which also moves about as the mirror is rotated; for the plane mirror it always moves with the light on the face, and for the concave mirror in the opposite direction.

Fig. 53.



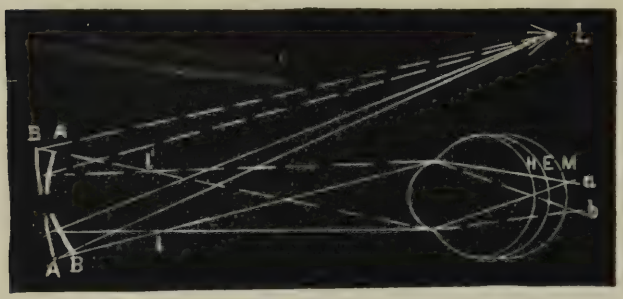
Retinoscopy with the plane mirror.

In Fig. 53 L represents the lamp-flame, screened from the patient, and A and B two positions of the plane mirror. When the mirror is at A, the light that enters the eye will come as though from a flame at l, and will be condensed toward a, on the lower part of the retina. At this time the light falls on the lower part

of the face. But when the mirror is rotated to *B*, the light entering the eye comes from the direction *l'*, and is condensed toward *b*, on the upper part of the retina. And at the same time the light thrown on the face has moved up to the upper portion of it. The positions of the retina in hypermetropia, emmetropia and myopia are shown at *H*, *E*, and *M*. It will be noted that in all these forms of ametropia, the movement of the light on the retina is the same, that is, *with* the light on the face.

In Fig. 54 the action of the concave mirror is represented. When the mirror is at *A*, the light that enters the eye comes

Fig. 54.



Retinoscopy with the concave mirror.

from the focus of the mirror at *l*, conjugate to the position of the lamp-flame, and is condensed toward *a*, on the upper part of the retina; and when the mirror is at *B* the light enters from *l'*, the new position of this conjugate focus, to be condensed toward *b*, on the lower part of the retina; that is, as the light has moved upward on the face, it has moved downward on the retina, and this is true for either *H*, *E*, or *M*. In the following account it is supposed that the plane mirror is used.

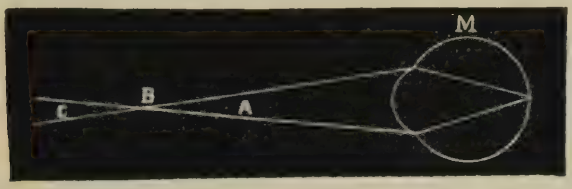
To employ the concave mirror, it is only needful to remember that the apparent movement of the light in the eye is always just the opposite of that given for the plane mirror.

We have thus seen what is the *real* movement of the light on the retina, as it would always appear in the back of an enucleated eye with the sclera and choroid removed, but the surgeon does not see it in that way; he can only watch the *apparent*

movement as seen through the pupil. This will be the same as the real movement, with the light on the face [plane mirror] when he sees an erect image, and in the opposite direction when he sees an inverted image.

In Fig. 55, *M* represents a myopic eyeball, from the retina of which rays come out and are focused at *B*, the *point of re-*

Fig. 55.



Rays coming from a myopic eyeball.

versal. Anywhere closer to the eye than this, as at *A*, an erect image is seen; the light in the pupil seems to move *with* the light on the face. Anywhere beyond the point of reversal, as at *C*, an inverted image will be seen, and the light in the pupil will appear to move *against* the light on the face. Just at the point of reversal *B*, it is impossible to see which way the light moves, and the illumination of the pupil is very feeble.

At one or two dioptres from the point of reversal the light is comparatively bright. As the examiner goes farther than this from the point of reversal, it becomes more and more feeble. With the same movement of the mirror the apparent movement of the light in the pupil is quicker as the point of reversal is approached. These variations in the degree of illumination and rapidity of movement aid the expert retinoscopist to a diagnosis, but the thing mainly depended on is the direction of the movement.

Application in Myopia.—If the surgeon, on throwing the light into the eye, finds that its apparent movement in the pupil is against the light on the face, he must be farther from the eye than the point of reversal (*B*, Fig. 55); so he approaches the patient, still rotating the mirror and watching the apparent movement of the light, until he finds this is with the light on

the face (*A*). He is now closer to the patient than the point of reversal, and should draw back and observe the greatest distance (*A*) at which this movement with the light on the face can be distinguished; then, drawing farther back, he observes the nearest point to the eye (*C*) at which the inverted movement can be seen, and the point *B*, half way between *A* and *C*, is to be taken as the point of reversal. These observations should be repeated until the exact position of *B* is established. The distance from *B* to the eye is then measured; it is the focal distance of the glass required to correct the myopia. For instance, if the erect movement is seen as far as 55 cm. from the eye, and the reversed movement as near as 80 cm., the point of reversal will be about 67 cm., and the myopia, therefore, 1.50 D.

If the myopia thus discovered is high, its amount can be most accurately determined by putting on a concave lens that will correct all of it but 1 or 2 D, measuring what is left by retinoscopy, and adding this to the strength of the lens used for the total myopia.

If, on the other hand, the myopia is very low, the point of reversal may be at so great a distance that when near it one cannot see which way the light is moving in the pupil. In this case a weak convex lens must be placed before the eye, the point of reversal found with the lens, and then the strength of the lens deducted from the myopia this indicates.

Application in Hypermetropia.—Here the rays from the retina emerge divergent, as shown by the broken lines in Fig. 56, and there can be no point of reversal. The surgeon finds the apparent movement of the light in the pupil is with the light on the face, and it continues to be so, no matter how far he draws back. It is necessary, then, to place a convex lens *L* before the eye, strong enough to render the rays convergent, and so to make a point of reversal. This lens does two things: First, it overcomes the divergence of the rays; this takes part of its power. Second, the remainder of its power makes the rays converge, causing a sort of artificial myopia. The point of reversal (*B*) obtained is the point for this artificial myopia. It is to be determined as for natural myopia, and the amount of myopia it represents deducted from the total strength of the lens. The

remainder will be the power required to overcome the divergence of the rays, and the strength of lens needed to correct the hypermetropia.

Fig. 56.



Rays emerging from a hypermetropic eye.

For example, suppose the movement of the light in the pupil is found at all distances to be with the movement of the light on the face, and on placing a 5 D convex lens before the eye, it is found to be still with the movement of the light on the face when the examiner approaches to a little within one metre, but appears reversed if looked at from a distance slightly greater than one metre. The point of reversal then is at one metre; 1 D of the strength of the lens is making the rays convergent, while the other 4 D have been used to overcome the divergence of the rays as they came from the eye. Therefore, the eye must be 4 D hypermetropic. For accuracy, it is better here, as in the case of natural myopia, to make the final determination with a lens that brings the point of reversal 1 or 2 metres from the eye.

Application in Emmetropia.—The application of retinoscopy is precisely the same as in hypermetropia; but it is found that the artificial myopia caused by the convex lens equals the full strength of the lens, proving that the rays must have emerged from the eye parallel.

Application in Regular Astigmatism.—The principles involved and the methods to be employed are essentially the same as in myopia or hypermetropia; but the refraction has to be determined in the principal meridians, instead of in any meridian indifferently, as it can be where all meridians are alike. To determine the refraction in a certain meridian the light must be

made to move back and forth in that particular meridian, by rotating the mirror about an axis at right angles to it.

The direction of either of these principal meridians is revealed by the area of light in the pupil assuming the form of a more or less distinct *band of light*, extending across the pupil in the direction of this meridian, when its point of reversal is approached. For the higher degrees of astigmatism this band is very noticeable, and fixes with the greatest accuracy the direction of the principal meridian. When the band-like appearance is most noticeable, it is easy to cause its apparent movement from side to side; but it is more difficult to distinguish the movement in the direction of the length of the band. Still, this latter movement is the one that is to be especially watched, and its reversal-point determined.

When the amount of astigmatism is very low, the appearance of a band may be very indistinct, or not at all perceptible; but in such cases it is found that when we have reached the point of reversal for movement of the light in one direction, there is still distinct movement, either direct or inverted, in the direction at right angles to this, and we thus know we have tested one meridian of an astigmatism, and must in the same way ascertain the point of reversal for the other at right angles to it. When the surgeon is closer to the eye than the point of reversal for either meridian, the movement will be with the light on the face in all directions. When he is at the point of reversal for the meridian which has its point nearer to the eye than the other meridian, there will be no distinguishable movement in this direction, but still a direct movement at right angles to it. When he is between the two points of reversal, there will, in the direction of the nearer meridian, be an inverted movement of the light, but in the other meridian a direct movement. When the farther point of reversal is reached the direct movement in its meridian ceases, while the movement in the other meridian continues inverted. When the surgeon has drawn back beyond both points of reversal the movement is reversed in all directions.

Having determined the amount of myopia, natural or artificial, in both principal meridians, the strength of the cylinder required to correct the astigmatism will of course be the difference

between the refraction for the two meridians. Having thus ascertained it, it is well to put this cylinder before the eye and to see if it does accurately correct the astigmatism, giving the same point of reversal for all meridians of the cornea; and, for accuracy, the spherical lens which will bring this point of reversal to the distance of 1 or 2 metres should be used with it.

Application in Irregular Astigmatism.—If the pupil is dilated, it will always be found that the refraction of the eye varies in different parts of it, so that points of reversal for different parts of the pupil lie at different distances in front of the eye; and at the point of reversal and near it, both direct and reversed movements of the light are visible at the same time in different parts of the pupil. Usually, there is at the centre of the pupil a considerable area that has about the same point of reversal, and this is the part to which attention should be paid, the refraction in the other parts of the pupil being of less practical importance.

When this central area of the pupil differs materially in refraction from the ring that surrounds it, the eye is said to present *aberration*, which is called *positive* when the centre of the pupil is more hypermetropic or less myopic, and *negative* when the opposite is the case. When the aberration is high, on examining it from near the point of reversal of the margin of the pupil, the movement of the light will be swift at the margin, and slow in the centre, making it look as if the light in the pupil were wheeling around a fixed point at the centre. This appearance is marked in conical cornea. Aberration of moderate degree causes the appearance of a ring of light at the margin of the pupil, which has a very distinct movement, when the point of reversal for the centre of the pupil has been reached.

In practising retinoscopy with the concave mirror, besides having the apparent movements of the light reversed, we are unable to vary our distance from the patient's eye. It is therefore needful to vary the point of reversal to bring it to the observer's eye by changing the glass before the patient's eye.

The Use of Mydriatics.—In addition to the local medicinal value of the mydriatics in the treatment of diseases of the eye, *e. g.*, iritis, these drugs are employed as aids of an accurate

determination of ametropia. With the ophthalmometer, without the aid of mydriatics, and with the method of retinoscopy, in the absence of prolonged mydriasis, good results are obtained; but it is a safe rule in all cases of suitable age, and in the absence of contra-indicating symptoms, to employ an active mydriatic before attempting to select correcting lenses. This remark applies particularly to cases of astigmatism. The mydriatic accomplishes three purposes :—

(*a*) It dilates the pupil, and permits a thorough exploration of the interior of the eye, as well as a more perfect examination of the lens and vitreous humor than could be obtained without its aid. The student should not, of course, think it necessary to dilate the pupil of each eye which he subjects to an ophthalmoscopic examination; but glasses should never be adjusted without a thorough knowledge on the part of the examiner of all the details of the eye-ground and the transparent media.

(*b*) It paralyzes the action of the ciliary muscle and places the accommodation in abeyance, rendering manifest types of ametropia which otherwise would remain latent.

(*c*) It fulfils the important function of giving, during the time of its action, physiological rest to the eye that is under its influence, and consequently helps to subdue any retino-choroidal disturbance or other congestive condition that pre-existing eye-strain may have originated. No matter how perfect the correction of an optical error may be, if the coats of the eye are not in a healthy condition, or have not received a tendency to reach such a state, the correcting lenses will not be comfortable.

In practice, various mydriatic drugs are employed, the most common being atropine, hyoscyamine, hyoscine, duboisine, and homatropine.

(1) *Atropine.*—Atropine is usually employed in a strength of four grains to the ounce. A drop of such a solution dilates the pupil in about fifteen minutes, and a very few moments later begins to paralyze the accommodation, which sustains a full paralysis in about two hours. The effect of atropine upon the accommodation remains for a week, but if, as is commonly the case, the drug is used for several days at a time, this influence is

much prolonged, and full return to the previous power of accommodation is not secured for about twelve or fourteen days.

In using atropine drops for the purpose of correcting errors of refraction, a solution of the strength given above should be dropped into the eye, one drop at a time, three times for at least a day, preparatory to the determination, and in young subjects possessing hypermetropic eyes, with active ciliary muscles, especially if there is associated spasm of accommodation, the drug must be continued for several days, or even longer, before the desired result is reached.

(2) *Hyoscyamine* is usually employed in the strength of two grains to the ounce, in the same manner. It produces wide dilatation of the pupil and complete ciliary paralysis, the effect of which is from six to seven days in duration. Many surgeons prefer this drug to atropine, and believe that its effects are equally good, while it enjoys the advantage of a much more temporary action upon the function of the ciliary muscle. The salt must be neutral, and the solution filtered through neutral paper (Risley).

(3) *Hyoscine* and *Duboisine* have precisely similar actions, the latter drug being even more transitory than hyoscyamine in its effect, return to accommodative power occurring in from four to five days. Both of them have the disadvantage of producing marked constitutional disturbances, at times rendering their employment disadvantageous.

(4) *Homatropine* is a drug which produces a very transitory effect upon the ciliary muscle, full return of accommodation occurring in about seventy-two hours after the last instillation.

It order to use this drug, it must be employed by cumulative instillations in the strength of eight to sixteen grains to the ounce, one drop of such solution being used every ten or fifteen minutes for an hour and a half preceding the determination, and then waiting forty minutes. At the end of this time the maximum effect of the drug upon the accommodation is secured. In the opinion of some surgeons, this drug is an insufficient paralyzer of accommodation, but if caution in regard to the cumulative instillations is observed, and the rule given above carefully followed, very satisfactory results may be obtained. Both its mydriatic and cycloplegic effects are increased by add-

ing to it a two per cent. solution of cocaine. Its influence may be neutralized by eserine.[1]

It is not safe to use strong mydriatics in elderly people, and they must never be employed if there is any symptom of glaucoma. It is unnecessary to use them when that age has been reached after which the accommodation is so weakened that hypermetropia ceases to be latent.

Cocaine, in addition to its anæsthetic action, is an excellent mydriatic, but its effect upon the accommodation is so slight that it is valueless for the purpose of preparing an eye for the estimation of any error of refraction.

[1] For further information in regard to the comparative value of the mydriatics the student should consult the valuable papers on the subject by Dr. S. D. Risley, in the Transactions of the American Ophthalmological Society.

CHAPTER IV.

NORMAL AND ABNORMAL REFRACTION.

BY JAMES WALLACE, M.D.

Emmetropia.—The normal eye produces a distinct image of external objects on the retina, particularly that portion of it situated at the posterior extremity of the visual axis.

The formation of the image is accomplished by the cornea, crystalline lens, aqueous humor, and vitreous humor. The cornea is the principal lens when the eye is at rest, as it separates two media with the greatest difference in density, and therefore has a higher refracting power than the crystalline lens. But the crystalline lens possesses the important function of accommodation, and approaches during the maximum of this function very closely to the refractive power of the cornea.

The cornea is not exactly spherical in curvature, but is an ellipsoid of revolution. In order to form a distinct retinal image, it is necessary that the curvature of the meridians should be symmetrical; any departure from this produces variations in their refractive power. The plane of the lens must be perpendicular to the visual line, and its different sectors must have a uniform density in the corresponding layers. The focal length of the dioptric apparatus of the eye must coincide with the length of the visual axis.

The *emmetropic* eye has a range of vision from infinity to its near point. (See table, page 49.) No glass improves distant vision, and spectacles are not required for reading until the age of 45 or 50 years is reached. The average length of the emmetropic eye is 22 mm., but it is possible for an eye to be emmetropic with a longer or shorter axis, if the curvature of its lenses varies in proportion.

Emmetropia, in the strict sense of the term, is the condition midway between hypermetropia and myopia, and its claim to

the title of normal refraction is denied, as it is not common to find people absolutely emmetropic. Experience shows that the more nearly an eye approaches to emmetropia the healthier are its membranes, and the more comfortable is its possessor in prolonged exercise of this organ. No great departure from emmetropia can exist without producing serious disturbance in the function of vision, and in the condition of the choroid and retina. One of the most important points in the treatment of eye diseases is to restore the eye to a condition of emmetropia by suitable glasses, and while this statement admits of modifications, in most cases it still remains the broad rule of practice. Anomalies of refraction lie at the root of 50 per cent. or more of all the diseases of the eye.

Emmetropia is that refractive condition of the eye in which the length of the visual axis corresponds exactly with the focal length of the dioptric apparatus when at rest; the far point lies at infinity, and the eye, in its condition of minimum refraction, is adapted to bring parallel rays to a focus on the retina. The principal focus, therefore, lies on the retina.

When these conditions are not fulfilled the eye is said to be *ametropic.*

Ametropia.—*Ametropia is any departure from exact correspondence between the length of the visual axis of an eye, and the focal length of its dioptric apparatus when at rest.* The principal focus does not lie on the retina.

It is comprehensible that the dioptric apparatus may remain unaltered, while the eyeball increases or diminishes in length: this is denominated *axial ametropia;* or, the eyeball remaining unchanged in the length of its axis, the curvature of its lenses may undergo variations, constituting *curvature ametropia.*

Ametropia is of three kinds. In the first class the refractive power of the eye is too weak, or the axis is too short, so that the principal focus of the eye falls beyond the retina. This is termed **Hypermetropia,** or **Far-sightedness.**

In the second class the refractive power of the eye is too strong, or the axis of the eye is too long, causing the principal focus to fall in front of the retina. This is termed **Myopia,** or **Near-sightedness.**

The third class comprises **Astigmatism.**

It is convenient to distinguish the first two classes of ametropia by the relative position of the principal focus to the retina.

Hypermetropia.—*Hypermetropia is that form of ametropia in which the principal focus of the eye lies behind the retina. The visual axis of the eye is shorter than the focus of its lenses in their condition of minimum refraction.*

The far point of the eye is negative, and is represented by the point behind the eye, to which rays must converge, before entering the eye, in order to be united on the retina. The refractive apparatus of the hypermetropic eye, in a condition of minimum refraction, is adapted to bring rays converging to this point to a focus on its retina. Rays passing out of a hypermetropic eye have a divergence as if they came from this point.

The eyeball may be abnormally short, constituting *axial hypermetropia;* a deficiency of 1 mm. in the length of the optic axis produces 3 dioptres of hypermetropia: or its refractive power may be deficient, *curvature hypermetropia;* an increase of 1 mm. in the length of the radius of curvature of the cornea produces a hypermetropia of 6 dioptres.

Cause.—Hypermetropia is nearly always congenital, and nearly all eyes are hypermetropic at birth. The eyeball increases in length with the development of the rest of the body, and hypermetropia diminishes, passes into emmetropia, or, more rarely, into myopia. Eyes are said to become hypermetropic after 55 years of age; but in many cases the hypermetropia has existed from early life, as latent hypermetropia, and now becomes manifest at an advanced age. Senile changes in the crystalline lens may produce the very opposite condition—myopia—as in the first stages of cataract. The extraction of the lens after cataract produces hypermetropia.

Symptoms.—Hypermetropia renders it difficult to maintain a distinct image of small objects, *e. g.*, printed matter, for any length of time: vision blurs, the subject is compelled to stop reading, and rub the eyes. This, for the moment, suffices to clear the vision; but the trouble recurs again and again, the accommodation becomes exhausted, and finally the work must be discontinued. The affected persons often hold a book or small objects in a strong light. The pupil in this way contracts, and vision is

rendered clearer. Many hypermetropic children bring their books close to their eyes, and, by contracting the palpebral fissures, are enabled to see better than with the book at a greater distance, because the object is seen under a larger visual angle, and the narrow slit between the lids cuts off the more divergent rays. These children are often erroneously supposed to be near-sighted, and concave glasses are given to them, which increase the trouble, instead of mitigating it.

Hypermetropia often gives rise to *spasm of the accommodation*, owing to the persistent contraction of the ciliary muscle necessary to overcome the error of refraction. This condition simulates myopia, distant vision becomes indistinct, but is sometimes improved by concave glasses. These glasses should never be given, as they only aggravate the trouble. Spasm of the accommodation is very annoying to the physician and distressing to the patient. It is prone to occur in individuals of neurasthenic condition. The spasm bears no relation to the vigor of the accommodation. The reverse is often true, that persons of relatively feeble accommodation have a marked cramp of the ciliary muscle. Spasm of accommodation is not, however, limited to hypermetropia.

As a result of hypermetropia the coats of the eye become inflamed. Conjunctivitis, blepharitis, and congestion of the retina and choroid are very frequent complications. Persistent headache, aggravated by using the eyes, various nervous symptoms, reflex in their nature, as well as disturbances in the visual function, are the common results of uncorrected hypermetropia. Convergent squint nearly always is accompanied by hypermetropia.

Hypermetropia is divided by Donders into *facultative*, *relative*, and *absolute*. Facultative hypermetropia may be overcome by the accommodation without squinting; relative hypermetropia can be overcome by the accommodation only when the subject squints inwards; and absolute hypermetropia cannot be overcome by the accommodation. In early life nearly all hypermetropia is facultative, but in advanced age even hypermetropia of low grades becomes absolute.

Hypermetropia is also divided into *manifest* and *latent*. The manifest hypermetropia is represented by the strongest convex

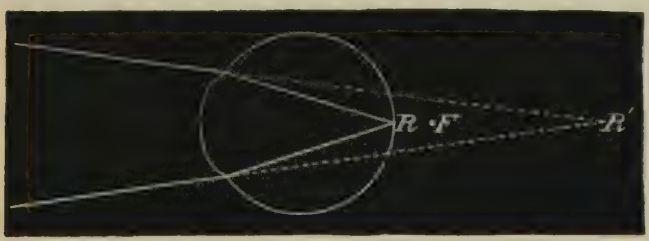
lens through which an eye, without the influence of a mydriatic, retains distinct distant vision. The latent hypermetropia is the amount in excess of the manifest, developed by the action of the mydriatic. The manifest and the latent together form the *total* hypermetropia.

Determination of Hypermetropia.—Hypermetropia always exists: When distant vision is improved by a convex glass; when the patient can read fine print through a convex glass at a greater distance than its focal length; when with the ophthalmoscope the interior of the eye, otherwise normal, is seen distinctly with a convex lens; and usually when the near point lies at a greater distance from the eye than is proper for the age. (See also *Retinoscopy*.)

The presence of any or all of these conditions makes it proper to employ a mydriatic, for the purpose of uncovering latent hypermetropia, unless the patient has reached his fiftieth year, at which age most of the hypermetropia is manifest. In young people, and in cases of spasm of the ciliary muscle or congestion of the choroid, it is often necessary to continue the use of the mydriatic for a longer period than under ordinary circumstances, and at the same time to administer alteratives.

Correction of Hypermetropia.—The principal focus F, of the hypermetropic eye, lies behind the retina. Consequently,

Fig. 57.



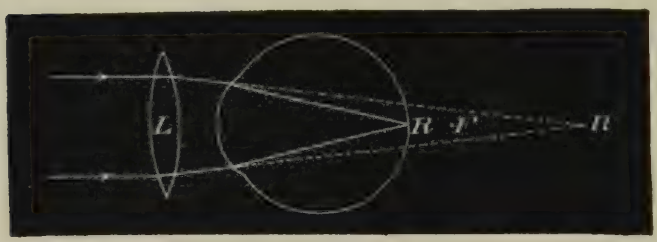
Far point of a hypermetropic eye. Rays from R on the retina of the hypermetropic eye after refraction diverge; these rays, prolonged backwards, would unite at the point R'. R' is the far point.

the retina R is situated within the principal focus, and its conjugate focus or far point R' is virtual. (Fig. 57.) Rays from R

seem, after refraction by the eye, to have come from R'; conversely rays converging to R', after refraction by the eye, unite in R on the retina. The rays which come from the retina R, of such an eye, after emerging from the eye are divergent, and prolonged backward would unite in the point R'. The distance of this point from the cornea is the focal length of the glass which corrects the hypermetropia. The amount of divergence of the emergent rays is dependent on the degree of the hypermetropia, that is, the distance R lies in front of F. The higher the degree of hypermetropia is the farther R lies in front of F, and the nearer the point of divergence R' lies to R; conversely, the lower the degree of hypermetropia is, the nearer the point R lies to F, and the farther back the point R' lies. The distance of R' must be less than infinity; otherwise, the eye would be emmetropic.

If parallel rays are given a convergence to the point R' by a con-

Fig. 58.



Correction of hypermetropia by a convex glass. The lens L gives to parallel rays a convergence towards the point R'; they will consequently be united on the retina R'. R' is the virtual conjugate focus of R.

vex lens placed before the eye, the rays will come to a focus at the point R on the retina, since the path of the rays passing into the eye after refraction by a convex lens (Fig. 58) is exactly the same as that of the rays diverging from the retina and passing outwards (Fig. 57); only the direction is reversed. The far point R' of the hypermetropic eye is the point to which parallel rays must be given a convergence by a convex lens in order to come to a focus on the retina. The amount of this necessary convergence represents the deficiency between the refraction of the hyperme-

tropic and that of the emmetropic eye; the degree of hypermetropia is therefore in an inverse ratio to the distance of R'.

To correct hypermetropia the refraction of the eye must be increased by a convex lens of sufficient strength to bring F on the retina. This glass corrects the hypermetropia by shortening the focal length of the dioptic apparatus to correspond exactly with the length of the visual axis. The far point R' is removed to infinity. Parallel rays come to a focus on the retina without any effort of accommodation, and rays emerging from the eye are rendered parallel.

In order to neutralize the hypermetropia, that convex glass must be selected which gives the greatest visual acuity. As the greatest visual acuity is obtained when the retinal image is sharply formed, and as this occurs when rays are brought to an exact focus on the layer of rods and cones, the maximum visual acuity is the most satisfactory evidence that rays are exactly focused on the retina. If these rays are parallel, the glass which brings them to a focus on the retina corrects the hypermetropia. Rays from objects at 6 metres distance are sufficiently parallel for this purpose.

The card of test letters, in good illumination, is hung on a wall, at this distance from the patient. A pair of trial frames is placed before the patient's eyes and one eye at a time examined, the other being screened by an opaque disc. The patient is supposed to have his accommodation paralyzed by a mydriatic, or to be beyond 50 years of age. He is required to read the smallest letters which he can see distinctly on the card. The resulting sharpness of vision is noted. Usually the degree of hypermetropia may be closely estimated by observing the diminution in visual acuity. A convex glass is now placed before the eye; this is stronger in proportion to the reduction of vision. If the convex glass improves vision, but does not raise it to normal, stronger lenses are tried until the one is obtained which yields the maximum visual acuity; or, if the stronger glasses do not improve the vision, successively weaker ones are tried until that glass is found which gives the greatest sharpness of sight. This is the lens which corrects the hypermetropia. If the acuity of vision is raised to normal by a convex spherical lens, it is not likely that astigma-

tism is present, but every case should be examined with a view to discover any astigmatism. If none exists, the convex glass is all that is required to correct the ametropia. The examination should be repeated two or three times to insure accuracy.

In the absence of a mydriatic and the presence of some accommodative spasm, vision being equal in the two eyes, a more suitable glass may often be obtained by testing both eyes simultaneously, because with parallel axes the accommodation is more likely to undergo relaxation. This effect may be further secured by placing a prism of 2° or 3° (centrads) before one eye with its base inwards. The effect of this is to relax the internal recti muscles and indirectly the accommodation. It is a good plan to begin by placing before the eyes a lens of stronger refraction than the one required, and gradually weakening it by concave glasses of successively higher numbers until normal vision is reached. The glass required is then the difference between the two.

The proof that the glass selected is the correct one depends upon the ability of the patient to focus parallel rays on the retina. Parallel rays may be obtained by placing an object at the principal focal distance of a convex lens. The principal focal distance of a 4-dioptre lens is 25 cm. Therefore, if the glass corrects the hypermetropia, the patient should be able to read fine print at 25 cm. distance with + 4 dioptres added to his correction. If he reads at a greater distance than 25 cm., some hypermetropia is still uncorrected. If he reads at a nearer distance than 25 cm., the hypermetropia is probably over-corrected.

The degree of hypermetropia may be determined by placing a convex lens before an eye whose accommodation is paralyzed, and by finding the distance at which small type appears most distinct. Suppose the lens selected is 4 dioptres (focal distance = 25 cm.), and that the patient reads best at 33 cm. Now 33 cm. is greater than the principal focus, and the rays therefore are convergent after passing through the lens, since a 3-dioptre lens would render them parallel; 4 dioptres = 3 + 1 would give them a convergence of 1 D to the conjugate focus, 1 metre back of the eye; one dioptre therefore represents the amount of the hypermetropia (see page 144).

Rule: Subtract from the lens employed, the lens whose focal distance equals the distance at which the patient reads. The difference is the degree of hypermetropia.

It is often necessary to correct hypermetropia in children before they are old enough to read. The ophthalmoscope and retinoscopy are the means upon which reliance is placed. The method of determining ametropia by retinoscopy is elsewhere explained (see page 128).

After the degree of the hypermetropia has been determined, the very important question presents itself, what glass shall be ordered? While the eye is under the influence of atropia, distant vision is distinct with the full correction; after the effects of the atropine have disappeared, it is often dim with the full correction, and a haze seems to lie over all distant objects which disappears when the glasses are removed. On the other hand, the headache, asthenopia, and congestive troubles return if the hypermetropia remains uncorrected. The spasm of accommodation is the disturbing factor in this problem, and it is so variable in different individuals that no precise rule can be given. Many people wear a full correction with comfort, and do not need any modification. On the other hand, others will tolerate but a small part of the correction, and then only after treatment by prolonged mydriasis, alteratives, and tonics.

There are two methods of dealing with this difficulty. First, to order full correction while the eye is still under the influence of mydriatic, and to insist that this shall be worn constantly during the time that the accommodation is returning to its normal state. If, when the eye has regained its usual condition, in the course of from one to two weeks, the distant vision remains dim, the glasses may be weakened sufficiently to secure normal acuity of sight for long ranges. The instillation of eserine will often assist in soothing the irritability of the ciliary muscle. It is not necessary to use this drug until a week or ten days after the mydriatic has been stopped. The strength employed is from gr. $\frac{1}{32}$ to gr. $\frac{1}{6}$ to the ounce of water, preferably the weaker solution.

It should be borne in mind, as Jackson insists, that the glass which gives the best correction at 4 or 6 metres is not the cor-

recting glass for the total H, but in reality is an over-correction of $\frac{1}{4}$ to $\frac{1}{6}$ D. Strictly speaking, rays coming from these distances are not parallel, and the glass which focuses them perfectly on the retina will not perfectly focus parallel rays. Hence, in ordering a full correction, the glass which gives the best vision at 4 or 6 metres must be weakened by $\frac{1}{4}$ or $\frac{1}{6}$ D. If this fact were more often remembered, less difficulty would be experienced in attempting to cause patients to wear a full correction.

Second, the eyes are first allowed to regain their full power of accommodation, and an interval of time, from one to two weeks, allowed to elapse after the atropine has been discontinued, and before the eyes are tried for the glass which is to be worn. The full correction is placed in the trial frame, and vision tested. If the patient has normal vision with the glass, it may be ordered. If the vision is reduced by the full strength of glass, the patient is ordered the glass nearest in strength to full correction with which he still has normal visual acuity. This may be only one-half, one-fourth, or even less, of the full amount. It is necessary in these cases to increase the strength of the glass from time to time as symptoms of fatigue manifest themselves.

One very frequent cause of inability to wear a full correction depends upon insufficiency of the internal recti muscles (exophoria), causing an associated action of accommodation with the muscular effort necessary to bring the visual axes into a parallel condition. The optical centres of the glasses require the greatest attention, and frequently require displacement slightly to the inside (see page 185). When the glass ordered for distance is only a small part of the full correction, it is very often necessary to order another pair of lenses for reading which embodies nearly or quite the full amount of correction.

Some surgeons, instead of ordering the glass (nearest in strength to the full correction) with which the patient still has normal visual acuity, in each case systematically weaken the lens which neutralizes the total hypermetropia by a given amount, usually 0.75 D. Donders advised a glass based upon the manifest H, to which one-quarter of the latent H was added. Macnamara recommends, in absolute hypermetropia, the use of a convex glass, the strength of which shall be equal to one-half of the

sum of the manifest and total hypermetropia; *e. g.*, manifest H = 1.5 D; total H = 3.5 D. H. m. + H. t. = 5 D; ordered + 2.5 D.[1]

Fig. 59.



Angle gamma in hypermetropia. *O A*, the optic axis. *N*, the nodal point of lens. *V M*, the visual line, cuts the cornea at inner side of optic axis. *O N V*, the angle gamma, in this case is positive. *M*, the macula.

The visual line is often very much displaced to the inner side of the cornea in hypermetropia, causing a very large value of the angle gamma.

Myopia.—*Myopia is that form of ametropia in which the retina lies back of the principal focus of the eye, and only those rays which diverge from some point nearer than infinity can come to a focus on the retina. This is the far point of the myopic eye.*

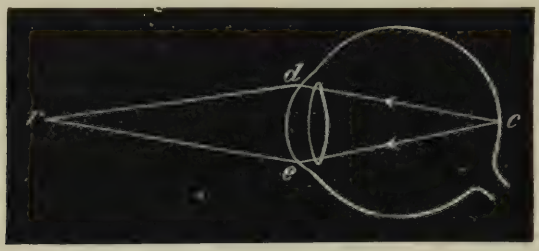
The far point, therefore, is limited by the amount of divergence necessary to bring the focus of the rays on the retina. The higher the degree of myopia is, the closer will the far point *r* lie to the eye. Rays coming from the retina converge to the far point and form there an image. (Fig. 60.) This image can be seen by the ophthalmoscope. The far point and the retina are conjugate foci.

Cause.—Myopia may be produced by increased refraction of the cornea, or crystalline lens, *curvature* myopia, or by too great

[1] The experience of the writer of this paragraph with the different methods has led him to adopt the plan of ordering full correction in all cases of hypermetropia. A large number of cases require no modification of the glass. It must be insisted, however, that the glass shall be worn all the time, and the spectacles so fitted that the patient cannot look over them. The convergence must be ample; any insufficiency may be compensated by prisms or tenotomy.

a length of the optic axis, *axial* myopia. In the great majority of cases myopia is due to elongation of the optic axis, often the result of pathological changes in the coats of the eye.

Fig. 60.



Far point of a myopic eye. Rays diverging from the retina *c*, will, after refraction, converge to *r*; conversely, rays diverging from *r*, will, after refraction, converge to *c*; *r* is the far point, *r* and *c* are also conjugate foci.

Myopia frequently is progressive, and the increased convergence rendered necessary by the near position of the far point seems to be a significant factor in the further production of myopia on account of the distention backwards which results from the compression of the ball between the external and internal rectus muscles. The sections of myopic eyes show a thinning posteriorly of the sclerotic and choroidal coats, proving that the elongation of the axis is due to a stretching of the coats of the eye. The choroid also gives evidences of being drawn towards the temporal side, producing a crescentic space at the outside of the nerve of a whitish hue, known as conus, or myopic crescent. The head of the optic nerve is often distorted in the same direction. These conditions are explained by excessive convergence and the resistance of the optic nerve. (Hasner, Weiss, quoted by Fuchs.)

Myopia is also occasioned by changes in the shape of the cornea as a result of disease. Conical cornea, by increasing the curvature as well as lengthening the axis, gives rise to myopia.

The principal theories which have been urged to explain the production of myopia are :—

(1) *The Anatomical Theory*, which ascribes the production of myopia to the incentive given by the shape and size of the orbit

to greater development of the eyeball. The size of the orbit is usually dependent on the conformation of the face.

(2) *The Mechanical Theory*, which ascribes the development of myopia to the compression of the eyeball by the muscles (the external rectus) producing distention of its coats backwards by the excessive convergence rendered necessary at the close distance at which myopes work. The external rectus winds around the eyeball like a band, in such cases.

The superior oblique, according to Stilling, is the principal muscle which compresses the ball in myopia. He thinks the low position of the trochlea increases the amount of force this muscle exercises on the ball. By the diminished vertical diameter of the orbit in myopes the trochlea has a lower position. In this way he believes he can predict in childhood those who will become myopic. Schmidt-Rimpler makes the vertical diameter of the orbit higher in myopia than in hypermetropia, and rejects Stilling's conclusions. Stilling's hypothesis, which is a combination of the anatomical and mechanical theory, leads to the conclusion that myopia is a question of race; that the broad, low face, of the German, for example, contains the conditions for the production of myopia, while the long, narrow face of the English or American disposes towards hypermetropia. The influence of race had been previously mentioned by Landolt, who says: "It is evident that myopia will be developed more rapidly in eyes that are already relatively long, *i. e.*, emmetropes and slight myopes, such as we find with a development of the skull in the antero-posterior diameter; thus, race becomes a factor, etc."

(3) *The Inflammatory Theory.*—The frequent observation by Graefe and others of choroiditis in the posterior portion of the eyeball, of areas of pigment absorption, and changes in the vitreous humor, has given rise to the belief that the existing choroiditis and scleritis are the essential factors in the production of myopia. These influences are traced to habits of life which promote fulness of the veins of the head and neck and hinder the egress of the blood from the eye, such as bending over a desk during study, as a result of disparity between the height of the desk and the size of the child, or from working in rooms with insufficient illumination. A disposition towards plethora

might in the same way dispose towards this congestion of the eyes. Sluggishness of the circulation, insufficient exercise in the open air, confinement in badly ventilated rooms, may easily increase the myopia, if they do not originate it. The fluids of the eye are increased in amount, the sclerotic becomes softened from inflammation and yields to the pressure from within. It is very probable that this is the cause of a large number of the cases of progressive myopia. As Landolt remarks, "no eye is safe from posterior choroiditis;" hypermetrope as well as myope falls under its baneful influence. Norris describes inflammation of the cornea, leading to softening, in variola, rubeola, and scarlatina. It is possible that these diseases may give rise to myopia by changes in the corneal curvature.

Prolonged use of the eyes at near work has been offered as an explanation of the way in which congestion is produced. Occupations which necessitate this are considered conducive to myopia; but, as Fuchs, Landolt, and Mauthner remark, "millions of people are engaged at such work, and only a fraction of them are myopic." The defenders of the mechanical theory of the production of myopia by compression of the eyeball between the muscles and a resultant distention consider the choroiditis a secondary result.

Those who think the choroiditis is the initial stage of the process look upon the lengthened axis as a result of the inflammation.

The largest number of myopes are to be found among the upper classes, and artisans whose work demands close inspection; but the highest grades of myopia appear to exist among the lower classes, who do not use their eyes for close work and have been free from the pernicious influence of school life. Donders has thus seen the highest grades among sailors and peasants, and other observers confirm this statement. Foerster remarks that myopia is produced at home and not in the school, and very truly states that the children are gathered in the evening to prepare their lessons around a table which is too high for them, the lamp being placed at the farther end for the convenience of the older members of the family; or the children creep into a dark corner to study, and the books are necessarily crowded close to their faces.

Among other causes of less significance may be mentioned unusually great distance between the pupils, rendering convergence more difficult; divergent squint and a large size of the angle gamma, in this case negative, also throw more strain on the eye muscles in convergence.

It is conceivable that after myopia is once produced, the eyeball, by its oval shape and greater size, may act as a cause of its further development by the increased muscular effort necessary to rotate such a ball inwards during convergence, and the compressing effect of the external recti muscles on the increased posterior segment of the ball. The strain on the accommodation has been urged as a cause, but as myopes do not have to accommodate, this argument loses much of its weight. The influence of heredity is felt here, as elsewhere. Persons with myopic ancestry seem to have a tendency towards myopia.

Myopia, rarely congenital, usually makes its appearance from the eighth year upwards, and sometimes is ascribed to a febrile attack. It is often the continuation of a process started in hypermetropic eyes, especially those with astigmatism, and the gradual transition from hypermetropia to myopia is not infrequently seen among patients who return for re-correction.

The prevalence of myopia in this country is distinctly less than in Europe. It is especially frequent in Germany, in the higher classes of the schools reaching, according to Cohn, 60 per cent. In 2582 eyes examined by the writer under atropine at the University Hospital, 287, or 11 per cent., were myopic or had myopic astigmatism; the remainder were hypermetropic.

Symptoms.—The symptoms of myopia range themselves under the two classes: subjective and objective.

The *subjective* symptoms are those which naturally arise because the range of vision is limited by a radius of a few centimetres. Distant objects are not perceived; the myope is surrounded by a fog. As soon as an object passes beyond his far point it becomes indistinct. He must either bring objects to his eyes in order to see them clearly, or else walk up to the objects. A high myope thus describes his sensations as a child: "If I dropped something on the floor, I could not recover it without going on my hands and knees, and moving my face along the floor, until I found it.

For this I was frequently whipped, as it was thought to be a bad habit."

Myopes have an inclination to avoid out-door sports on account of their poor vision, and exhibit a greater fondness for occupations which come within their range, *e. g.*, reading, drawing, etc., than for others which require good distant vision. The prolonged congestion of the eyes which such habits entail leads to increase in the myopia. Concave glasses, by widening the range of vision, enable the myope to take part in out-door occupations.

The *objective* symptoms of high myopia may embrace: (1) The prominent eyeball. (2) A somewhat stupid expression of the countenance from inability to note the expression in the face of others. (3) A peculiar manner of reading. The book is held stationary, and the face is moved from side to side following each word. (4) The enlarged optic disc, seen in the direct method, by placing concave glasses in the ophthalmoscope; and the inverted image of the fundus, obtainable by withdrawing the mirror some distance from the eye. (5) Divergent squint. This is frequently a sign of myopia. The squinting eye is often amblyopic. Binocular vision does not exist in such a case; the good eye, freed from the necessity of convergence, reads at the far point without any effort, and glasses for reading are sometimes unsatisfactory because the print appears smaller on account of its removal to a distance greater than the far point of the eye. If the acuity of sight is much diminished, this becomes a serious difficulty in the use of glasses, notwithstanding the increased area of vision which they afford.

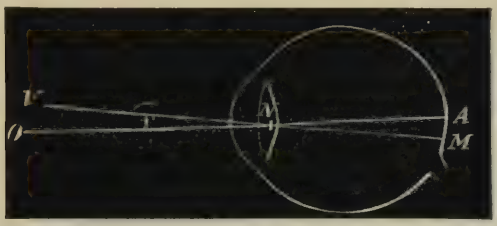
The visual axis in myopia sometimes passes through the cornea at the outer side of the optic axis; the *angle gamma* is then *negative*, and the eye in looking at a distant object turns inwards in order to bring the visual line to fix on it, giving rise to an apparent convergent squint. (Fig. 61.) This renders necessary a greater degree of convergence.

Myopic eyes are popularly considered as strong eyes, from the fact that they see fine print at close distances. This is true only in those cases in which the tunics of the eye have suffered no injury—where, for example, the myopia is of moderate degree and not due to disease.

Myopia does not decrease with age, but, on the contrary, increases.

The higher degrees of myopia (malignant myopia) are marked by ravages in the structure of the choroid and retina. The pig-

FIG. 61.



Angle gamma in myopia which is negative.

ment-cells wander off in some places and accumulate in others, producing marked contrasts in the appearance of the eye-ground. Large areas of atrophy, glistening white in color, alternate with black splotches, and at times hemorrhages occur. These changes are accompanied by diminished vision. The vitreous humor is fluid in some portions, and floating opacities are often visible, sometimes being so large as to obscure vision. Owing to the intimate relation between the visual purple and the pigmented epithelium of the retina, the loss of the epithelium is followed by diminution in the visual acuity. In higher grades of myopia —15 to 20 dioptres, and sometimes still higher—the condition of the eye is very desperate, and the morbid processes may culminate in detachment of the retina and complete blindness.

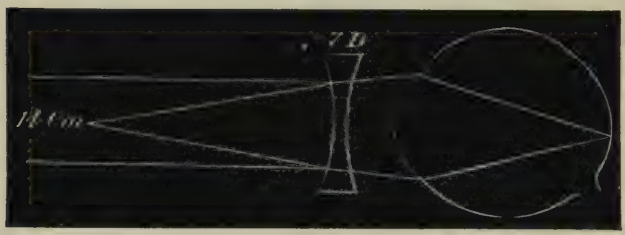
The ciliary body is feebly developed in myopia of considerable degree, as a result of which accommodation is very much diminished, and the anterior chamber is larger. For this reason the tendency to glaucoma in myopic eyes is said to be lessened.

DETERMINATION AND CORRECTION OF MYOPIA.—Myopia may be determined: (1) By the position of the *punctum proximum* of accommodation, which is closer to the eye than is normal for the age. (2) By the position of the farthest point of distinct vision obtained by test-types. (3) By the ophthalmoscope and retinoscope. (4) By the concave glass which gives

distinct vision at a distance of 6 metres. In all these methods we seek to obtain the degree of myopia by the amount of divergence which must be given to rays to enable them to meet on the retina.

In the myopic eye, only those rays which diverge from a distance not greater than the far point can be focused on the retina. In order to see at any greater distance than this the rays must be given a divergence as great as if they came from this point. (Fig. 62.) If the greatest distance at which a myopic eye can

Fig. 62.



Manner in which concave lens causes rays to diverge from the far point of a myopic eye.

see fine print is 14 cm., in order to see at a still greater distance the eye would require a concave glass which would give rays a divergence as if they came from this point. By dividing 100 by 14 we obtain the number of dioptres (7) necessary to produce this divergence.

In order to secure accuracy, it is necessary to bear in mind, as the far point is measured from the cornea, that the glass must be placed close to the cornea; if the glass is removed 1 cm. from the cornea, it is plain that its focal point will also be one centimetre farther away; therefore it is necessary to employ a glass of shorter focus.

Example.—Suppose it is desired to cause the rays to diverge from a point 14 cm. in front of the cornea, and the glass is to be placed at 1.5 cm. in front of the cornea: it is evident, under these circumstances, that the glass would require to have a focus of $14 - 1.50 = 12.5$ cm., or $\frac{100}{12.5} = 8$ dioptres.

The proper position for a glass is 13 mm. in front of the cornea.

In low degrees of myopia this does not affect appreciably the strength of the glass, but in the higher degrees it makes a serious difference. The concave glass is therefore somewhat stronger than the actual myopia, especially in the higher grades.

The degree of myopia may be determined approximately by this method more rapidly than by beginning the trial at 6 metres with glasses (in this instance, concave) in the manner described in connection with hypermetropia. One example will suffice :—

A patient reads fine print distinctly at 8 cm. from the cornea, but not at a greater distance ; the eye being under the influence of atropine, this is his far point. In order that he may see at an infinite distance, parallel rays must be given a divergence as if they came from 8 cm. in front of the cornea. As the glass will be placed 13 mm. in front of the cornea, its focal length must be 8 cm. — 1.3 cm. = 6.7 cm., or 67 mm. $\frac{1000}{67}$ mm. equals 15 dioptres, as the number of the concave lens required to permit distant vision. A lens of this number should be placed in the trial frame, and the vision determined through it by means of test-types at the usual distance. Perhaps a weaker or stronger lens may give better vision, and hence several numbers should be tried in succession, until that glass is selected with which the greatest acuity of vision is attained, and which then represents the correcting lens.

A patient often will select a glass of higher number than the one really required, because the letters have a blacker and sharper appearance when seen through concave lenses ; but unless the stronger glass at the same time secures for the patient an increased acuity of vision, it should be rejected, and the weaker lens adopted. If several lenses give equally good vision, the weakest one should be retained.

The method of determining the correcting lens in myopia by means of ophthalmoscopy and retinoscopy is elsewhere described. (See pages 116 and 128.)

The *position* of the lens used to correct high grades of myopia is of great importance. The nearer the lens is placed to the cornea the stronger it becomes ; conversely, the farther it is removed from the cornea the weaker it is. The strong concave lenses necessary to correct high degrees of myopia in this way may sometimes be utilized by the patient to gain artificial accom-

modation. By bringing them close to the eye, vision is adapted for distance; by pushing them from the eye, divergence is lessened and the eye is adapted for a closer point.

The visual acuity in high myopia is always reduced, and in those cases accompanied by changes in the retina and choroid this reduction assumes a considerable grade. Sometimes very slight improvement in distant vision is secured by concave glasses, and near vision may not be at all benefited. Under these circumstances patients see better by using one eye alone and bringing the print or other work close to the eye, because the enlarged retinal image compensates for the diminished visual acuity. These cases, however, are seldom encountered, and a concave lens, properly selected, almost always improves both near and distant vision.

Hence the *treatment* of myopia consists in the selection of suitable concave glasses, the object of which is to remove the far point sufficiently distant to prevent too great convergence, and at the same time demands the recognition and correction of any co-existing astigmatism.

In so far as the development of myopia is due to pernicious methods of reading and study, its *prophylaxis* should include attention to the following points: The correct position of the head and body during study; the employment of books with sufficiently large and distinctly printed type; and good illumination coming from behind the patient, preferably over the left shoulder. The reading-desk should be tilted upwards, so that the page may be parallel with the face, thus obviating the necessity of craning over the desk. The hours of study should be restricted within reasonable limits, and they should alternate with periods of rest and exercise, or employment in the open air.

It is during school-life, from the eighth to the eighteenth year, that myopia makes its progress. The illumination of the school-room, its ventilation, the proper height of the seat both in relation to the desk and to the floor, the correct slope of the desk, the size of the type in the school-books, and the hours of study, have all been carefully arranged with a view towards removing disposing causes. It is said that in Germany myopia

has already been diminished 6 per cent. by these hygienic measures. (Von Hippel.)

If a tendency to divergence exists in early life, it would be proper to remove this by tenotomy of the external rectus as a preventive measure against the development of myopia.

Ordering of Glasses.—After the estimation of the degree of myopia, the existence of astigmatism having been excluded, or, if present, corrected, the strength of the glass suitable for constant use, reading, or other special work must be determined. This is decided by the visual acuity, the range of accommodation, and the degree of the myopia.

Young people (under 20), with good vision and a moderate degree of myopia (under 5 D), may wear the full correction constantly if the accommodation is ample and no signs of fatigue are evident. In higher grades of myopia associated with lowered vision, it is often necessary to diminish the full correction from 1 to 3 dioptres. It is evident that the greater the visual acuity, the farther away the same size of type can be seen; hence the demand on accommodation is less as the visual acuity is greater.

As age advances, an additional glass should be ordered for reading which will give the patient a far point of from 30 to 60 cm. In order to obtain this, the full correction must be diminished from 1.50 to 3 dioptres.

The full correction may be allowed for distance, or for all purposes excepting close work, as long as the myopia remains less than 8 or 10 dioptres. In higher grades than this the glass for constant use should be reduced from 1 to 4 dioptres, because this variation in strength occurs according as the lens lies 1 cm. nearer or farther from the cornea. A glass of 10 dioptres (10 cm. focus), 1 cm. from the cornea, = a glass of 9 dioptres (11 cm. focus) close to the cornea; a glass of 20 dioptres (5 cm. focus), 1 cm. from the cornea, = a glass of 16 dioptres (6 cm. focus) close to the cornea. Hence the patient, by shifting the glass nearer the cornea, may increase its strength from 1 to 4 dioptres. Thus, in a case of myopia fully corrected by — 20 D, a — 16 D should be ordered for constant use, because, even if the patient then brings the spectacles closer to his eyes, their refractive power would not be too much increased.

Concave glasses diminish the size of the retinal image, especially when the glass is removed farther from the eye. The retinal image is larger in myopia than in emmetropia, but, if the correcting lens is exactly 13 mm. in front of the cornea, the image is of the same size as in emmetropia.

Concave lenses act as prisms when the visual line passes through any portion except the optical centre. The optical centres should always be separated by a space equal to, and never less than, the inter-pupillary distance, except in those cases of weakness of the internal rectus muscles where it is advisable to increase the distance between the centres. This produces the effect of a prism with its base inwards, that is, it lessens the amount of convergence which otherwise would be required. The deviation may be calculated from the focal distance of the lens, and the amount of decentering. The distance the optical centre is displaced, divided by the focus, equals the tangent of the angle of deviation.

A painful glare of light is often produced in myopes by wearing glasses for the first time. Noyes has an apt simile: "To the myope, taking off the glasses is sometimes like going out of the blazing sun into the shade." The same author suggests glasses tinted blue to modify this glare, which, he thinks, is due to the light reflected from large patches of choroidal atrophy. The use of weak eserine in narrowing the pupil is also a method which may be reccommended.

The reading-glasses for myopes are described under PRESBYOPIA.

Astigmatism.—In the preceding forms of ametropia, *H.* and *M.*, the cornea has been considered as an ellipsoid of revolution, so that planes passing through it in various directions, vertical, horizontal, and oblique, produce sections having an equal curvature. Equal refraction consequently takes place in these different planes. Variations in the curvature of the different meridians produce differences in their refractive power; in some of these meridians the eye must therefore be ametropic. Three conditions may arise:—

I. The eye may be emmetropic in one meridian and ametropic (either *H.* or *M.*) in the others.

II. The eye may be ametropic (*H.* or *M.*) in all meridians, but in different degrees.

III. The eye may be ametropic in all meridians, but in some *H.* and in others *M.* (*H.* and *M.*).

It is convenient to designate the different parts of the eye by imaginary lines, similar to those employed in geography.

The *axis* of the eye is a line drawn from the centre of the cornea through the centre of the ball. Passing through the centre of the lens and the centre of rotation, it penetrates the sclerotic between the optic nerve entrance and the macula. The anterior and posterior extremities of this line are the *poles* of the eye.

A great circle extending round the ball perpendicularly to the axis, and at an equal distance from the two poles, is called the *equator* of the eye; other great circles passing through the poles are called *meridians.*

The lens is described in a similar way by its axis, anterior and posterior poles, and equator.

When the meridians of the cornea have an equal curvature, the rays of light gather in one common focus. Frequently, the cornea has meridians of unequal curvature producing greater refraction in some meridians and less in others. The rays passing through the meridians of highest refraction reach their focus soonest, while those passing through the less refracting meridians come to a focus farther back.

Definition.—*The term Astigmatism is applied to that refractive condition of the eye in which a luminous point, for example a star, forms an image on the retina, the shape of which image is a line, an oval, or a circle, according to the situation of the retina, but never a point.*

Seat of Astigmatism.—Usually the cornea is the seat of astigmatism, but astigmatism may also be produced by an oblique position of the lens, or by the visual line passing eccentrically through the cornea.

When the meridians of the cornea progress evenly in their refraction from the lowest to the highest, the astigmatism is termed *regular.* When the curvature in different parts of the same meridian varies, and the meridians vary irregularly in their curvature, as the result of cicatrices from ulcers, or distention of the cornea from inflammation, the astigmatism is called *irregular.*

Almost all eyes possess more or less *irregular astigmatism.*

Usually it is only slight, and gives no serious inconvenience for ordinary vision, but all points of light, such as stars, distant street lamps, etc., shoot out rays and twinkle as the result of the irregular astigmatism of the eye. The seat of this irregular astigmatism is in the crystalline lens. In the lenses of young people the union of the sectors is visible by three faint lines—the lens-star (Fig 63);

Fig. 63.



Spectrum of lens showing sectors. (Donders.)

in the adult, secondary rays are also visible. Slight differences in the density of the several sectors are sufficient to produce a distorted image of a luminous point.

Principal Meridians.—In regular astigmatism the cornea has one meridian with the shortest radius of curvature producing the highest refraction, and another meridian, at right angles to this, with the longest radius of curvature, and the least refraction. These are called the *principal meridians*, and may be situated in any part of the cornea, but there is a disposition of the most

refracting meridian to lie in or near a vertical direction, and of the least refracting meridian to lie in a horizontal direction.

To simplify the phenomena of astigmatism the principal meridians will be considered as running vertically and horizontally with the greatest refraction in the vertical, and the least refraction in the horizontal meridian. It must be borne in mind that these meridians may be inclined to the perpendicular, or even reversed.

Form of the Image of a Point Focused by an Astigmatic Eye.—The rays passing into an astigmatic eye, thus considered, are most sharply refracted by the vertical meridian. The bundle of rays, instead of having a round section, forms a horizontal oval, which becomes smaller as the rays travel farther backwards; but the vertical diameter of the oval lessens most rapidly until, when the focus of the vertical meridian is reached, the figure becomes a horizontal line, because all the rays which pass through the vertical meridian are brought to a point, and only those diverge horizontally which pass through the horizontal meridian.

Farther backwards the vertical rays, after passing this focus, cross and diverge again vertically; the horizontal rays diverge less, and the figure becomes once more a horizontal oval.

Still farther, the figure assumes the form of a circle; the divergence of the horizontal rays becomes less, and that of the vertical rays more. The figure becomes next a vertical oval,

Fig. 64.



Retinal images of a point in the different forms of astigmatism. *A*, compound hypermetropic astigmatism. *B*, simple hypermetropic astigmatism. *C D E*, mixed astigmatism. *F*, simple myopic astigmatism. *G*, compound myopic astigmatism.

and then a vertical line when the focus of the horizontal rays is reached. Finally, the section is again a vertical oval, the horizontal rays, having passed their focus, cross, and once more diverge. (Fig. 64.)

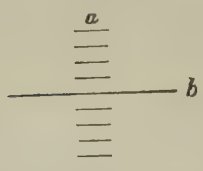
It is evident from this that no matter what position the retina may occupy, no distinct image can be formed upon it, but there must always be overlapping of the images of the different points of an object, causing a blur or a wrong impression of its outline.

Symptoms.—In this manner the acuteness of vision is diminished by astigmatism. Letters are not distinctly seen, some letters being confused with others—H and N, B and S, F and P, K and X, V and Y. The overlapping of the diffusion circles in the retinal image produces, in high degrees of astigmatism, an apparent doubling of the object. The indistinctness of vision compels a closer approximation of the object, with a consequent strain upon the accommodation.

Astigmatic people learn to overcome their astigmatism by contracting the lids close together in order to make a horizontal slit. The vertically divergent rays are thus excluded, and the eye, accommodated for the horizontally divergent rays, receives a more distinct though fainter image. There is an almost characteristic facial expression in astigmatism caused by the contraction of the lids.

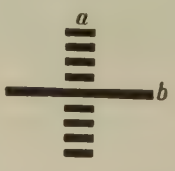
Astigmatism produces an indistinctness in the appearance of fine lines running in certain directions, the direction of the indistinct lines being determined by that meridian which has its focus on or nearest to the retina. This meridian, therefore, will most nearly approach emmetropia; the lines parallel to it will appear indistinct, while those parallel to the opposite meridian, or the one farthest removed from emmetropia, are most distinctly seen.

Fig. 65.



Horizontal lines focused by emmetropic vertical meridian.

Fig. 66.



Appearance of fine horizontal lines focused by ametropic vertical meridian.

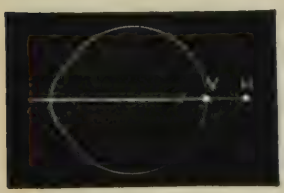
In those cases in which the horizontal meridian is emmetropic, and the vertical meridian ametropic, fine parallel lines (Fig. 65)

running in a horizontal direction will appear spread out into thick bars (Fig. 66), while vertical lines will appear distinct.

To understand this, the student should remember that rays diverge from a horizontal line in all directions; those which pass through the horizontal meridian, if they are not exactly focused, spread out in the direction of the line, causing its extremities to appear somewhat faint in outline, but do not blur its width. The rays which diverge in vertical planes from the different points in the line pass through the vertical meridian. If this is not emmetropic, the breadth of the line appears thicker; but if the vertical meridian is emmetropic it forms a distinct point in the image, of each point in the object, by bringing the rays which pass through it to a focus. A horizontal line thus appears as a succession of distinct points when the vertical meridian is emmetropic. Vertical lines, in the same way, appear most distinct when the horizontal meridian is nearest to emmetropia, or if oblique lines appear most distinct, the meridian at right angles to their direction is the one nearest to emmetropia. Luminous points are drawn out in the direction of the ametropic meridian, and luminous circles become elongated into ovals.

Regular Astigmatism.—Regular astigmatism is classified into five varieties, according to the relative position of the retina to the foci of the two principal meridians. The horizontal meridian is represented by *H.*, the vertical meridian by *V.*

Fig. 67.



Foci of the principal meridians in simple hypermetropic astigmatism.

Fig. 68.



Foci of the principal meridians in simple myopic astigmatism.

1. *Simple hypermetropic astigmatism.*—In this variety one meridian, usually the vertical, is emmetropic, and the horizontal meridian is hypermetropic. The focus of the vertical meridian

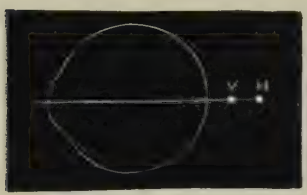
is on the retina, the focus of the horizontal meridian is behind the retina (Fig. 67); horizontal lines appear distinct.

2. *Simple myopic astigmatism.*—The focus of one meridian, usually the horizontal, is situated on the retina, while the focus of the vertical meridian lies in front of the retina. The vertical meridian is myopic, and the horizontal meridian emmetropic (Fig. 68); vertical lines appear distinct.

3. *Compound hypermetropic astigmatism.*—All meridians are hypermetropic, but usually the horizontal presents the greatest ametropia. The focus of each principal meridian is situated back of the retina, that of the vertical generally being nearest to it (Fig. 69); horizontal lines are usually most distinct.

4. *Compound myopic astigmatism.*—All meridians are myopic, but the vertical presents the greatest ametropia. Both principal

Fig. 69.



Foci of the principal meridians in compound hypermetropic astigmatism.

Fig. 70.

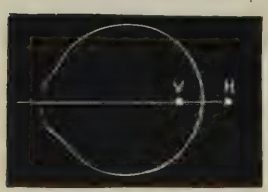


Foci of the principal meridians in compound myopic astigmatism.

meridians have their foci in front of the retina, that of the horizontal lying closer to the retina (Fig. 70); vertical lines are usually most distinct.

5. *Mixed astigmatism.*—The retina lies between the foci of the two principal meridians. The horizontal meridian is hypermetropic, and the vertical meridian is myopic (Fig. 71); no lines appear distinct, unless the eye simulates myopic astigmatism; in this case the vertical lines appear distinct.

Fig. 71.



Foci of the principal meridians in mixed astigmatism.

Recognition of Astigmatism.—Astigmatism is recognized *subjectively* by the greater distinctness of lines

which run in one direction, and the blurring of those lines which run in a direction at right angles to this. The vertical strokes of a letter may appear distinct, while the horizontal strokes are hazy. The figures on a clock dial sometimes appear more distinct at 12 and 6 than at 3 and 9, or any other two directions which are perpendicular to each other. For this reason astigmatic patients have sometimes imagined that their vision is better at certain hours of the day than at others. (Carter.)

A diminished visual acuity, unimproved by spherical lenses, in the absence of organic disease, usually is due to astigmatism. Patients frequently complain that letters have a streaked or smeared appearance. Small gas flames seem to be drawn out in one direction.

Astigmatism is recognized *objectively*, and its degree very closely estimated, by the ophthalmoscope, the ophthalmometer, and retinoscopy.

The optic disc has a characteristic appearance in astigmatism; its round appearance is altered to an ellipse, which is more elongated as the degree is greater. It appears as if a brush had been swept across it in the direction of its long axis; the retinal vessels appear in focus only in one direction at a time, and convex or concave glasses must be added to the ophthalmoscope to bring the other vessels into focus.

The long axis of the optic disc is usually vertical, and the vertical vessels appear as the most hypermetropic or least myopic, although the refraction of these meridians is just the opposite.

The explanation of this is, that the breadth of the vertical vessels is focused by the successive horizontal meridians. When the horizontal meridians are emmetropic, the vertical vessels appear distinct; consequently, if the vertical vessels are seen most distinctly with + 6 D, the horizontal meridian has a hypermetropia of that degree; or, if the horizontal vessels are most distinctly seen with — 2 D, the vertical meridian has a myopia of that amount. The horizontal vessels are focused by the successive vertical meridians.

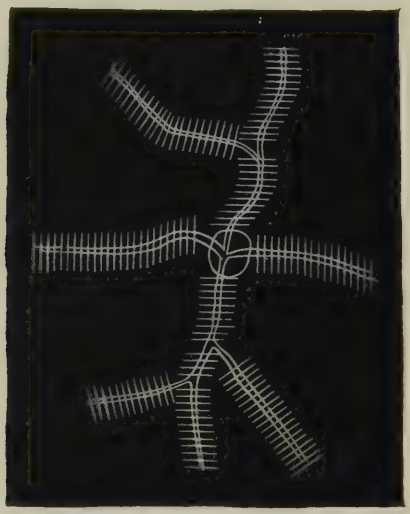
The disc is elongated in the direction of the meridian of greatest

curvature. The longer and shorter axes of the oval thus correspond with the principal meridians of curvature.

In order to estimate *astigmatism* with the *ophthalmoscope*, find the lens which gives a distinct image of the vessels running in the direction of the long axis of the oval; and then, in a similar way, find the glass with which a distinct image of the vessels at right angles to the first is obtained; the difference in refractive power between these two glasses is the degree of astigmatism. The ophthalmoscope must be brought close to the eye, and the strongest convex or the weakest concave lens is the measure of the ametropia.

In cases of compound hypermetropic astigmatism, both vertical and horizontal vessels are seen with a convex lens; but the vertical

Fig. 72.



Focusing of the vessels by the meridians of an astigmatic eye; the parallel lines on each vessel represent the direction of the meridians through which a distinct image of the vessel is obtained.

vessels are clearly seen with a stronger lens than the one with which a clear image of the horizontal vessels can be obtained. The difference between the two glasses represents the degree of astigmatism.

In compound myopic astigmatism, the vessels of both principal meridians are seen distinctly with concave lenses, but those which run in the horizontal direction usually require the strongest glass. The difference between the two glasses represents the degree of astigmatism.

When the vertical vessels are most distinctly seen with a convex glass, and the horizontal vessels with a concave glass, the astigmatism is still the difference between the two meridians; but, as the refraction in one meridian is *positive*, and in the other *negative*, the difference is represented by the sum of the two glasses. Thus, vertical vessels + 1.50 D and horizontal vessels — 1 D, would represent an astigmatism of 2.50 D. (Compare also page 121.)

In the indirect method of ophthalmoscopy, the astigmatic disc appears oval, but the long and short axes are reversed in direction when the auxiliary lens is held close to the eye. On removing it farther, the diameters change; the longer diameter becomes shorter, or the shorter becomes longer, or one diameter becomes shorter while the other grows longer, so that the oval is again reversed. (Compare also page 126.)

The *ophthalmometer* of Javal permits measurement of the corneal astigmatism by means of the changes which take place in the size of the reflected images of two test objects, on account of variations in the curvature of the corneal meridians. One important point in favor of this instrument, and one of its great advantages over the ophthalmoscopic determination of astigmatism, is that variations of accommodation in the patient's eye do not modify the degree of astigmatism. The curvature of the corneal meridians remains the same during active accommodation and during the passive state.

In many respects the most admirable test of astigmatism is by the method of *retinoscopy*. This is explained on page 133.

Correction of Astigmatism.—There are several methods by which we may proceed to measure astigmatism. Astigmatism may exist in a very low degree, associated with a much higher degree of hypermetropia or myopia, or a marked astigmatism may exist alone, or with ametropia of the other meridians,

or finally mixed astigmatism may be present. Each of these conditions requires a separate method of procedure.

1. In all cases of hypermetropia or myopia, after the highest visual acuity has been developed with spherical lenses, and even if the radiating lines on the dial appear equally distinct, a weak convex and a weak concave cylindrical lens should be alternately placed in the trial frame, in addition to the spherical lens, and their axes rotated through 180°.

If, by this manœuvre, vision is improved and the patient enabled to read another line of the test letters, astigmatism is present. For example, if the vision of a case of hypermetropia of 3 D is improved by a convex 0.50 D cylinder, with its axis vertical, the glass required is + 3 D sph. ⌒ + 0.50 cyl., axis 90° or vertical; but if in the same case the maximum vision previously obtained by + 3 D sph. is not improved by the addition of a convex cylindrical lens, a concave cylindrical lens is rotated throughout its axis until, if possible, the vision is increased. Suppose a concave cylinder of 0.50 D, with its axis at 180°, is found to improve vision or + 3 D sph. ⌒ — .50 D cyl., axis 180°. This result is expressed in a simpler form by + 2.50 D sph. ⌒ + .50 D cyl., axis 90°. (See page 40.)

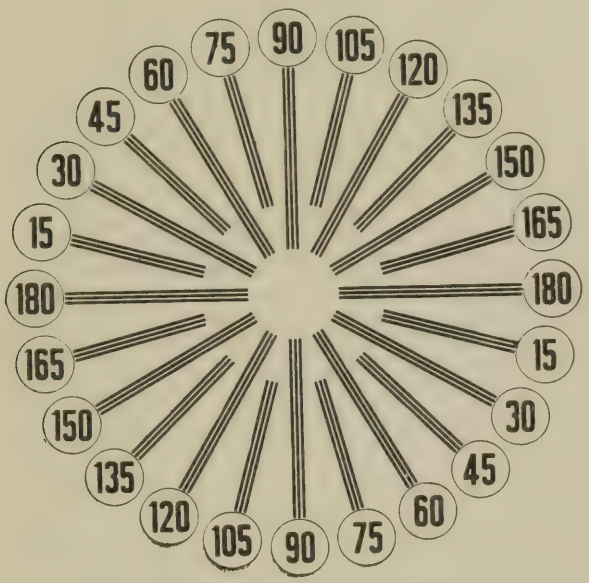
From this it is evident that any sphero-cylindrical combination, where the spherical is designated by a plus (+), and the cylinder by a minus (—) sign, unless the cylinder is stronger than the spherical, can be reduced to a simpler form, obtained by subtracting the value of the cylinder from that of the spherical; the difference is the strength of the required spherical lens. A cylinder of the same strength as the one first employed, with its sign changed to correspond to that of the spherical, and the axis reversed, completes the process. This method of correcting astigmatism is best adapted to those cases in which the degree is 0.50 D or less.

2. The position of the principal meridians is determined by means of the clock face, or Snellen's dial. (Fig. 73.)

The most distinct lines correspond to the most ametropic meridian; therefore, a stenopaic slit is inserted in the trial frame, in a direction at right angles to this. If vision is normal in this direction, the meridian must be emmetropic and the astigmatism

is simple. The slit is then turned at right angles to its previous direction, and the glass found which gives the highest vision.

Fig. 73.



Wallace's astigmatic chart reduced one-sixth.

The astigmatism is represented by this glass. The following are examples :—

Simple Hypermetropic Astigmatism.—The patient sees horizontal lines most distinctly ; the stenopaic slit is placed vertically in front of the eye : and through this $V = \frac{6}{6}$; with the stenopaic slit horizontally placed, $V = \frac{6}{9}$, with + 1 D added, $V = \frac{6}{6}$; hence + 1 D cyl., axis 90°, is the glass required.

Simple Myopic Astigmatism.—The patient sees vertical lines most distinctly ; the slit is placed horizontally : $V = \frac{6}{6}$; with the slit placed vertically : $V = \frac{6}{12}$; with — 1.50 added, $V = \frac{6}{6}$; hence — 1.50 cyl., axis 180°, is the glass required.

3. The patient may not perceive any difference in the distinctness of the radiating lines until a spherical lens is placed in front

of the eye, when some of them become more distinct than the others. The slit is now introduced in a direction at right angles to the distinct lines. Vision is not normal, but a spherical lens improves it, and that lens which gives the best vision with the slit in this direction is selected. The slit is then reversed. The visual acuity is less through the slit in this position than in the previous one, and a higher lens is necessary to secure the best vision. The astigmatism is represented by the difference between the stronger and weaker lens. This is an example of compound astigmatism, and is corrected by a spherical lens of the same strength as that which neutralizes the least ametropic meridian, and a cylindrical lens equal to the difference between the two meridians. The following are examples:—

Compound Hypermetropic Astigmatism.—No lines appear distinct, or perhaps the horizontal ones only slightly so, but a convex glass makes the horizontal lines decidedly more distinct than the others. The slit is introduced in a vertical direction: $V = \frac{6}{12}$; with $+1.50$ spherical added, $V = \frac{6}{6}$. The slit is now turned into a horizontal direction: $V = \frac{6}{30}$; with $+3.50$ D. sph. added, $V = \frac{6}{6}$. The glass required for such a case is $+$ 1.50 D. sph. $\supset$ + 2 D. cyl., axis 90°.

Compound Myopic Astigmatism.—No lines are distinct, but a concave spherical possibly makes the vertical lines more distinct, than the others, if the visual acuity is not too much lowered. The slit is introduced in the horizontal direction: $V = \frac{6}{0}$; with $-$ 5 D added, $V = \frac{6}{12}$. The slit is now placed vertically: $V = \frac{6}{0}$, $-$ 7 D is added, and V rises to $\frac{6}{12}$. The glass required is $-$ 5 D sph. $\supset$ $-$ 2 D cyl., axis 180°.

All that has been said pertaining to the selection of glasses in myopia applies equally here. It is often impossible to correct the astigmatism by this method, and recourse must be had to the first method by developing the best possible vision with spherical lenses, and then adding cylinders to still further elevate the visual acuity.

Mixed Astigmatism.—Hypermetropia exists in one principal meridian, and myopia in the other. Usually no set of lines appears plainer than the rest, but the addition of a concave or

convex spherical brings out some lines more distinctly than the others. Thus a clue to the principal meridians is obtained. With the slit before the eye, a convex spherical lens is placed in position and the slit rotated until the vision becomes more distinct. The hypermetropic meridian has then been found.

Example: Suppose the hypermetropic meridian to be horizontal, and V to be most improved by + 3 D. The slit is turned to the vertical position, and it is found that a — 4 D gives the best vision. The difference between these two meridians is 7 D. A + 7 cylinder, axis 90°, placed before such an eye would produce a myopia of 4 D, while a — 7 cylinder, axis 180°, would produce a hypermetropia of 3 D, consequently with the + 7 cylinder, we must associate a — 4 spherical, and with the — 7 D cylinder, a + 3 D spherical. Such a case could be corrected by either of the following formulas: + 3 D sph. ⌒ — 7 D cyl., axis 180°; or — 4 D sph. ⌒ + 7 D cyl., axis 90; or by means of two cylindrical lenses with their axes at right angles to each other, viz., + 3 D cyl., axis 90 L — 4 D cyl., axis 180°.

The spherical lenses may be weakened to meet requirements of the accommodation, but it may be accepted as a broad rule, with few exceptions, that the astigmatism is to be fully corrected if the degree can be definitely determined.

After the correction has been determined by any one of these methods, trial by one of the other plans should be made, in the hope of still further improving vision, because the highest visual acuity is always to be regarded as the best evidence of the accuracy of the glass. When the correct glass has nearly been reached, the final selection is made by comparing the vision through this lens with the next weaker and the next stronger number, always deciding in favor of the weaker cylinder, unless the vision is distinctly improved by the stronger glass.

The following additional facts concerning lenses require mention: If a sphero-cylinder is in position before an eye, and vision is improved by placing before it another cylinder of the same sign (+ or —), with its axis at right angles to that of the first, it shows that a stronger spherical and weaker cylinder are required.

If vision is improved by placing in position another cylinder of the same sign, with its axis parallel to the first, it shows that the same spherical with a stronger cylinder should be adopted.

If vision is improved by placing in position another cylinder

of different sign, with its axis parallel to the first, it shows that a weaker cylinder with the same spherical is needed.

If vision is improved by placing in position a cylinder of different sign, with its axis at right angles to the first, it shows that a weaker spherical with a stronger cylinder must be employed.

Ordering of Glasses.—Glasses are ordered for astigmatic eyes under the general rules which govern the selection of glasses in hypermetropia and myopia. For distance, the full correction is ordered in myopic astigmatism and in mixed astigmatism; in hypermetropic astigmatism, the spherical lens is sometimes weakened. In myopic astigmatism, the spherical lens is weakened for near work. Simple myopic and mixed astigmatism give an opportunity for simplifying reading glasses. This will be mentioned under Presbyopia.

Irregular Astigmatism.—A low degree of this defect exists in nearly all eyes, but it does not interfere with good vision. When its degree is increased by irregularities of the corneal surface from ulcers and cicatrices, the vision is very much reduced. Sometimes one meridian of regular curvature can be found, and by means of a cylindrical lens vision can be improved Stenopaic spectacles render vision more distinct, but they embarrass the wearer by limiting the field of vision. An iridectomy sometimes improves vision very much by displacing the pupil towards a more regular portion of the cornea.

Anisometropia.—Under this term are considered those cases in which one eye is much more hypermetropic or myopic than its fellow, or where myopia exists in one eye and hypermetropia in the other. Inasmuch as the correcting lens, placed at the anterior focus of the eye, produces images on the retina, of equal size, in all forms of ametropia, no theoretical reason exists for not correcting both eyes. It is often best to leave it to the sensations of the patient. If there is discomfort with an attempt at binocular vision, one eye may be corrected and the other suffered to remain without a correcting glass. Frequently patients are more comfortable when both eyes are corrected.

Presbyopia.—The accommodation diminishes gradually from early life onward, and the near point recedes farther from the eye with each succeeding year. As long as it remains within 20 or

30 cm., no appreciable inconvenience in reading is noticed; but when the near point has fallen off to a greater distance than this, it is not possible to read fine type without the aid of convex glasses, unless the visual acuity is much above the average. This condition is termed *presbyopia*, and is a normal result of growing old.

Causes.—The cause of presbyopia consists in hardening of the crystalline lens, which is thus prevented from assuming the increased convexity which constitutes the essential factor of accommodation.

This increase of convexity, necessary for seeing near objects, must be supplied to the eye by a spectacle lens. In the first stages of presbyopia, while considerable accommodation still remains, a weak convex lens is required, which enables the person to see near objects by rendering the rays less divergent, as if they came from a somewhat greater distance.

When the accommodation is entirely obliterated at 75 years of age, the convex glass must be stronger. The rays are now rendered parallel, as if they came from an infinite distance. In order to produce this, the object must be held at the focus of the lens. There is, therefore, no range of vision.

In the earlier stages there is still a range of vision from the focal distance of the glass to the near point. A person who has an accommodation of 3 dioptres, and requires + 1.50 D in addition, will have a range from the focal distance of the glass $\frac{1 \text{ metre}}{1.50} = 66$ cm. to his near point through the glass; 3 D + 1.50 D = 4.50 D; $\frac{1 \text{ meter}}{4.50} = 22$ cm.

Patients occasionally postpone the time of wearing reading glasses, by holding fine objects in a bright light, the resulting contraction of the pupils rendering vision more distinct.

Presbyopia usually begins at the age of 45. Unusual visual acuity, or vigor of accommodation, however, enables a person to dispense with glasses for several years longer. A visual acuity of $\frac{6}{4}$ enables its possessor to see the same object distinctly at 30 cm. which another individual with an acuity of only $\frac{6}{6}$ would

have to hold at 20 cm. Presbyopia is to be distinguished from hypermetropia, which is often latent and confounded with it. Correction of hypermetropia restores the far point of the eye to infinity.

Correction of Presbyopia.—The correction of presbyopia is determined after the eye has been rendered emmetropic by neutralizing any hypermetropia which may exist. Presbyopic correction brings the near point closer, but it also diminishes the distance of the far point.

It is necessary to observe caution that unduly strong glasses are not employed in approximating the near point, lest the far point be brought too close and serious discomfort ensue. Most people read at an average distance of from 30 to 40 centimetres. In early presbyopia, considerable range of vision exists on either side of these points; but at 60 years and later there is little play, and the near point and far point are very close together. Unless there is diminished visual acuity, at this age the glass should be given with which the patient reads best at a distance of 30 to 40 centimetres.

The refraction of the eye should be rendered normal by correcting all hypermetropia and astigmatism. The management of myopia under these circumstances will be elsewhere considered.

The *near point* of vision should be carefully determined for each eye separately. The ability to read 1-metre type at 30 cm. is not equivalent to the act of accommodating for 30 cm.; in order fairly to accommodate for 30 cm. the patient should be able to read type which represents normal vision at 30 cm. (See page 47.) If the accommodation is normal, the near point will correspond closely with the figures given in the table. The additional refractive power required may then be calculated.

Table of the position of near point at different ages.

Age.	Accommodation.	P.
45	3.50 dioptres	29 cm.
50	2.50 "	40 "
55	1.75 "	57 "
60	1 "	100 "
65	.50 "	200 "
70	.25 "	400 "
75	.00 "	∞

At the age of 45 it is usually necessary to supply a + 1 dioptre spherical lens for reading, provided the eye is emmetropic; if the eye is hypermetropic, 1 dioptre + the correction for the hypermetropia; if myopia exists, + 1 dioptre is not required. Plus 1 dioptre added to the 3.50 dioptres of accommodation which the eye possesses at 45 years = 4.50 D; this brings p to 22 cm. $\left(\frac{100}{4.50} = 22\right)$, and r to 100 cm.

At 50 years of age + 2 dioptres are usually required, with the same modifications in case of hypermetropia or myopia. This glass, added to the accommodation which the eye possesses at 50, viz., 2.50 dioptres, also makes 4.50 D; this brings p to 22 cm., but r is now only 50 cm. distant.

At 55 years, + 2.50 D is the glass usually required, which, added to the accommodation (1.75), gives a refractive power of 4.25 D; p = 23.5 cm., r = 40 cm. If stronger lenses than this are used, r is brought still closer, and the patient is forced to hold his book near the face. So long as $V = \frac{6}{6}$, it is not necessary to order any stronger glass than this. Sometimes + 3 may be more satisfactory and may be ordered, but most people prefer a glass which enables them to read, resting the book on the lap or the arm of a chair. It is once more reiterated that these glasses are for emmetropic eyes. In hypermetropia with presbyopia, they are to be added to the hypermetropic correction.

As visual acuity diminishes, a stronger lens is necessary to enable the object to be held closer, and thus subtend a larger visual angle. The glass may be increased to 4, 5, 6, or even 8 dioptres. The strong glasses necessitate the close approximation of the object and a corresponding diminution in the field of vision. The only rule in the selection of such glasses is to give that glass which affords the necessary vision with the least inconvenience. With very great diminution of sight, requiring glasses of 8 or 10 dioptres, binocular vision is impossible, and the better eye should be supplied with a correcting glass, and the other excluded from vision.

With binocular vision, the reading glasses for the two eyes should be equal in strength; consequently, when a different

degree of ametropia exists in the two eyes, a corresponding difference should be made in the reading glasses.

Sometimes modifications are required in the strength of the glass, to suit particular vocations; for example, reading music, working at a bench, etc. Under these circumstances, it is necessary to ascertain the distance from the eye at which the work is placed, and to order a glass, whose focal distance is not less, but, if possible, somewhat greater than the distance required.

In myopia, myopic astigmatism, and mixed astigmatism, the rules for the selection of reading glasses call for particular mention. Patients with low degrees of myopia, not higher than 2 D, do not require reading glasses at as early an age as emmetropic or hypermetropic subjects.

The amount of myopia may be considered the equivalent of the convex glass suitable for the correction of the presbyopia. A myopia of 1 D, consequently, would enable a person to attain the age of 50 without the necessity of reading glasses. At that age he would require + 1 D for reading, and at 55 + 1.50 D, and at 60, possibly + 2 D, depending upon his visual acuity. A myope of 2 D could dispense with reading glasses until the age of 55 (often until a later period); then he would require + .50 D; at 60, possibly + 1 D. A myope of 3 or 4 dioptres never becomes presbyopic in the ordinary sense; he can read at any age without glasses. In early life he may wear his correction for distance and reading; later on it is better for him to read without glasses.

In higher degrees of myopia, it is necessary to order a concave glass from 2 to 5 dioptres less than the full correction. The age has little influence on the amount of reduction; myopes practically do not accommodate; the degree of myopia and the visual acuity are the two important factors. A concave glass is given which will extend the far point to a comfortable distance. A myope of 6 dioptres would probably require from — 3 to — 4 dioptres for reading; a myope of 10 D, about — 6 dioptres, and a myope of 15 or 20 dioptres would require a reduction of 5 or 6 D from the full correction. In these high grades, V is much reduced, print cannot be seen unless held close to the eye, so that extension of the reading distance is out of the question. The

farthest point at which a book can be read should be determined, and a glass given of the same length of focus. Prisms are often necessary. When the vision is much reduced, myopes will sometimes read best with one eye without the aid of any glass.

A patient with simple myopic astigmatism usually reads best with a convex cylinder of the same number, its axis being reversed. Thus, a patient whose myopic astigmatism is corrected by — 2 D cyl., axis 180°, will be comfortable with a + 2 D cyl., axis 90°. This glass with the myopic astigmatism produces a myopia of 2 dioptres in all meridians, and because the patient has been accustomed to see through a myopic meridian, he prefers this glass to the concave cylinder which makes him accommodate. As a rule, simple myopic astigmatism may be utilized to determine the reading glass in patients who have reached the age of 35, provided its degree is not too high. A convex cylinder, of a strength equal to the concave cylinder, with its axis reversed, will be sufficient.

If the degree of myopia thus produced is too great for comfortable reading, a concave spherical lens may be added to the convex cylinder. Thus, an astigmatic eye corrected by a — 4 D cyl., axis 180°, would probably require — 1.50 D sph. ⌒ + 4 D cyl., axis 90°.

If the degree of astigmatism is unequal in the two eyes, a spherical lens is required over one eye to equalize the refraction.

For example: (1) R. E. — 5 D cyl., axis 180°. L. E. — 3 D cyl., axis 180°. This case requires a — 2 spherical to be added to the right eye, viz., — 2 D sph. ⌒ + 5 D cyl., axis 90°, to make its refractive power equal to that of the left, 3 D cyl., axis 90°.

(2) R. E. — 1 D cyl., axis 180°, L. E. — 2.50 D cyl., axis 180°. In this instance, according to the circumstances, age, etc., one of the following combinations may be ordered: R. E. + 1 D cyl., axis 90°, L. E. — 1.50 D sph. ⌒ + 2.50 D cyl., axis 90°; or R. E. + 1.50 D sph. ⌒ + 1 D cyl., axis 90°, L. E. + 2.50 D cyl., axis 90°. Both of these combinations equalize the refraction of the two eyes, the first by producing in each eye a myopia of 1 dioptre, the second a myopia of 2.50 dioptres.

When, in cases of compound myopic astigmatism, the myopia amounts to several dioptres, the reading glass is secured by a sufficient reduction of the strength of the spherical without change of the cylindrical lens.

When, in lower degrees of compound myopic astigmatism, it is desirable to increase the refraction one or more dioptres, the procedure is somewhat different. Thus, if the combination is — 0.50 D sph. ⌒ — 1 D cyl., axis 180°, and the spherical lens is omitted, + 0.50 dioptre is gained; by substituting for the concave cylinder a convex cylinder with its axis reversed, an additional gain of 1 dioptre is secured; + 1 D cyl., axis 90°, in this case is equivalent to adding + 1.50 D sph. to the original combination. If still more refractive power is desirable, *e. g.*, + 2 D, + .50 D sph. ⌒ + 1 D cyl., axis 90°, gives the additional amount.

In another combination, — .75 D sph. ⌒ — 4 D cyl., axis 180°, it is desired to add + 2.50 D for reading. Dropping the — 0.75 D spherical, + 0.75 D of refractive power is obtained; substituting for the concave cylinder, convex 4 D cyl., axis 90°, + 4 D more are gained, making + 4.75 D. This is too high, hence it would be necessary to combine — 2.25 D sph. ⌒ + 4 D cyl., axis 90°, in order to obtain the desired + 2.50 D. A simpler method of procedure in this case would be to drop the — .75 D spherical; the uncorrected myopia would then furnish .75 D of the requisite 2.50 D, leaving 1.75 to be obtained. A + 1.75 D added to the — 4 D cyl., axis 180°, would make the proper combination.

In mixed astigmatism, a combination of spherical lens and cylinder is usually employed, and by using a concave spherical and convex cylinder we can easily find the combination necessary to produce any additional refractive power.

If the myopia produced by the convex cylinder alone is greater than the power of the lens it is desired to add, a concave spherical equal to the difference is given, thus: To the combination — 3 D sph. ⌒ 5 D cyl., axis 90°, it is desirable to add + 2 D. — 3 + 2 = — 1, hence — 1 D sph. ⌒ + 5 D cyl., axis 90°, is the glass required. Again, to — 1 D sph. ⌒ + 3 D cyl., axis 90°, it is desirable to add + 2.50 D. — 1 + 2.50 = + 1.50,

hence + 1.50 D sph. ⌒ + 3 D cyl., axis 90°, is the necessary glass. The myopia is in this case insufficient.

It is a point of some importance, in ordering reading glasses containing cylindrical lenses, to give attention to the relation of the axes of the cylindrical lenses. It has been assumed, for the sake of simplicity, that the axes of convex cylinders are placed at 90° and the axes of concave cylinders at 180°; this is commonly so, but the exceptions are numerous. It is a frequent condition in astigmatism to have one principal meridian inclined 15° to the right of the vertical in one eye, while the meridian of the same refraction in the other eye is inclined the same amount to the left of the vertical. This produces no serious disturbance in wearing the glasses if they are properly centred, although at first a rectangular figure appears like a rhombus. In a little time the eyes adapt themselves to the glasses, and this appearance is lost.

When the meridians of similar refraction are at greater angles than this, especially if the cylindrical lenses are strong, there is often inconvenience in wearing them on account of the prismatic deviation and the unequal distortion of objects which cylindrical lenses produce. Occasionally the axes are as much as 90° apart, one at 45° and the other at 135°, or one at 90° and the other at 180°. The glasses now deviate rays from an object in different directions, according as the eye looks through the glasses above or below the optical centres, or to the right or left of them. Such a case would be represented by + 3 D cyl., axis 180°, in right eye, and + 3 D cyl., axis 90°, in left eye. The difficulty is not obviated by ordering a formula like the following: R. + 3 D cyl., axis 180°, L. + 3 D sph. ⌒ — 3 D cyl., axis 180°, because the same displacement results. It will be found that the best solution of this difficulty is to ascertain the distance from the eye at which the person usually holds the book, and the relative position it occupies to the eye. The direction of the visual lines may thus be determined, and the optical centres of the glasses should be so placed that the visual lines will pass through them. There is then no deviation. Of course this renders necessary a separate pair of glasses for reading. When cylindrical lenses with axes in unusual directions are required

for distance, the optical centres should bear the same relation to the visual lines in distant fixation. These disturbances are aggravated by removing the glass farther from the eye, and conversely the trouble diminishes as the glass is brought nearer to the eye.[1]

SPECTACLES AND THEIR ADJUSTMENT.

After the refraction of the eye has been determined and the proper combination of lenses selected, the glasses should be properly ground, mounted in spectacle frames, and correctly adjusted to the patient's eyes. Patients should not be allowed to wear glasses until the surgeon has satisfied himself that the formula for the lenses has been faithfully followed by the manufacturing optician.

In order to do this, he proceeds as follows: If a simple spherical lens has been ordered, this and a spherical lens from the trial case, of the same number but opposite refractive character, are placed in close contact and some distant object observed through the combination, while the glasses at the same time are gently shaken up and down, and moved to and fro. If the glass is correct, this manœuvre has no influence upon the size or position of the object, which appears exactly as it would if it had been looked at through a piece of plane glass. The glasses are then said to neutralize each other. If the lens ordered does not neutralize the test-glass from the trial box, a weaker or stronger number is tried until the glass is found which produces complete or nearly complete neutralization. We convince ourselves in this way whether the glasses are correct or faulty. Thick bispherical lenses of different refractive character will not neutralize each other entirely even if they are of the same number. The convex lens always preponderates.

If a cylindrical lens has been ordered and has been correctly ground, it will be neutralized by a cylinder of the same number but of opposite refraction with its axis turned to the same angle

[1] Interesting papers on this subject are found in the Archives of Ophthalmology, Vol. xviii., No. 1, by Dr. J. A. Lippincott, of Pittsburg; and in the Ophthalmic Record, Vol. i., No. 1, by Dr. G. C. Savage, of Nashville, Tenn.

as that of the lens ordered. On shaking these two lenses, which are placed in contact, there should be no motion of the object viewed through them. The direction of the axis of a cylinder may be determined by finding the position in which the lens may be shaken without producing any motion of the object. For example, if the axis of the cylinder is vertical, no motion in the object looked at would occur when the spectacle lens is moved up and down. A line drawn on the glass with a pen marks this, and by placing the lens thus marked on a protractor the degree of the angle may be read off. The best object for thus testing a cylinder is the edge of a door or wall. To determine the strength of a cylindrical lens it simply is necessary to find the spherical or cylindrical lens which neutralizes the motion of the edge of a door viewed through the cylinder when this is shaken at right angles to its axis. The axis of the cylinder should be held parallel to the edge of the door and the glass moved in a horizontal direction.

A combination of spherical and cylindrical lenses is to be tested by a spherical lens held on the spherical surface of the spectacle lens, and a cylindrical lens held at the cylindrical surface of the spectacle lens, proceeding in the manner just described.

The *optical centre* is now to be determined, and this can be done by reflection. The surgeon stands with his back to a window, and finds the point on the lens where the image of the window-bars from the anterior surface, and the image from the posterior surface, overlie each other; the optic axis must unite these two points, and the optical centre is on this line. A more simple method is to find two meridians of the lens at right angles to each other through which a vertical line is not displaced horizontally, as each meridian is brought parallel with the vertical line. The intersection of these meridians is the pole or summit of the lens; the axis of the lens passes through this point, and the optical centre is on this axis between the two surfaces. If the lens is a cylinder or sphero-cylinder, the two meridians must be chosen, which are respectively parallel and at right angles to the axis of the cylinder.

In order to find the centre of a lens, it is held by the edges between the finger and thumb, and, care being taken not to hold it

obliquely, it is passed from right to left until the test object (edge of a door or wall) forms a continuous line above the lens, through the lens, and below the lens. If the axis of the lens is not exactly in line with the edge of the door, the part seen above and below the lens will not coincide with the part seen through the lens. When a continuous line is obtained through the lens with the object above and below, the lens should be marked with a line drawn across its surface over the part where the edge of the door or wall is seen, just as the outline of a figure is traced on a transparent plate. The glass is now turned around so that the line is at right angles to its former position; another portion of the lens is found through which the edge of a door is also seen in a continuous line with the part above and below. This is traced on the glass with ink, and the intersection of the two lines thus traced marks one extremity of the axis of the lens. In most lenses the distance from the surface to the centre is so slight that we may consider this point on the surface as the centre, and each lens should have its centre marked by a dot of ink. Strong lenses may be centred more easily, by using the window-bars, while the glass is held close to them, or the edge of a card or sheet of paper, which is laid on the desk. Still greater accuracy may be obtained by using a card, on which two lines are drawn, crossing each other at right angles; both principal meridians may in this way be found at once; the optical centre then lies over the intersection of the lines.

The spectacles should now be placed on the patient, and the position of these centres in relation to the pupil carefully noted. The patient is first asked to look across the room; the centres of the pupils should correspond with the dots on the glasses. Next, the patient is required to look at the finger of the surgeon held at 40 cm. distance, and it will be noticed that the centres of the pupils and the dots no longer coincide, but that the former have passed to the inner side of the latter. If the glasses are for distance or for constant wear, the space between the centres of the lenses should be the same as the inter-pupillary distance; if the glasses are for reading alone, the distance between the centres must be lessened. The ordinary reading distance being 40 cm., the visual lines converge to this point, and the farther

the glasses are from the centre of rotation, the nearer the centres should come to each other; therefore, it is necessary to make the distance between the centres of the reading glasses from 2 to 4 mm. less as compared with those of distance glasses, so that the visual lines may pass through these centres.

When glasses are ground with badly placed centres—that is, too far apart or too close together—the most unpleasant consequences may arise: obstinate diplopia, severe neuralgia, and tendency to squint. Patients are often unable to wear a correction, which otherwise would afford the greatest benefit, because the lenses are centred so badly that the straight muscles of the eye are kept on a strain in order to relieve the diplopia which the prismatic effect of the lenses produces. The centre of the pupil deviates inwards about 1 mm. in fixing at a point 40 cm. distant, as the pupil is 11 mm. in front of the centre of rotation; a glass placed 13 mm. in front of this would require its optical centre to be 1 mm. farther inwards than the pupil; 2 mm. in all. The two centres should thus be 4 mm. nearer together in reading glasses than in those for distance.

The inter-pupillary distance should be carefully measured to determine what the distance should be between the centres of the glasses. It is difficult to find the centre of a dilated pupil, and hence the margin of the iris on the right side of each pupil may be selected. The patient should observe some distant object while the inter-pupillary distance is measured during distant fixation, and then fix his eyes on the finger-tip of the observer, held about 30 cm. from his eyes while the measurement is noted during convergence. There should be a variation of 2 mm. between these two measurements. If the difference is greater than this, there is a probability that the patient has an insufficiency of convergence, and, in this case, the centres of convex glasses should be brought closer together; those of concave glasses placed farther apart.

In order to ascertain the amount of deviation which is produced by decentering a spherical lens, the following tables, which have been prepared by Dr. Edward Jackson, will be found useful, together with the descriptions of the tables taken from Dr. Jackson's paper.

In Table I., the first column gives in dioptres the strength of the lens to be used. At the head of each of the other columns is given the prismatic deviation required. The method of obtaining this is pointed out below; the columns give the respective distances in millimetres that the optical centres must be removed from the visual axis to produce such an effect.

TABLE I.—*Decentering required to produce a given deviation.*

	DEVIATION REQUIRED.							
Lens . . .	0.5° d.	1° d.	1.5° d.	2° d.	2.5° d.	3° d.	4° d.	5° d.
	AMOUNT OF DECENTERING NECESSARY.							
1 D . . .	8.7	17.5	26.2	34.9	43.6	52.4	69.9	87.5
2 " . . .	4.3	8.7	13.1	17.5	21.8	26.2	34.9	43.7
3 " . . .	2.9	5.8	8.7	11.6	14.5	17.5	23.3	29.2
4 " . . .	2.2	4.4	6.5	8.7	10.9	13.1	17.5	21.9
5 " . . .	1.7	3.5	5.2	7	8.7	10.5	14	17.5
6 " . . .	1.5	2.9	4.4	5.8	7.3	8.7	11.6	14.6
7 " . . .	1.3	2.5	3.7	5	6.2	7.5	10	12.5
8 " . . .	1.1	2.2	3.3	4.4	5.4	6.5	8.7	10.9
9 " . . .	.9	1.9	2.9	3.9	4.8	5.8	7.8	9.7
10 " . . .	.9	1.7	2.6	3.5	4.4	5.2	7	8.7

In Table II., the first column gives, as before, the strength of the lens; the head of each of the other columns shows the refracting angle of the prism equivalent to the amount of decentering indicated by the figures beneath, which indicate in millimetres the distance the optical centre is to be removed from the visual axis.

TABLE II.—*Decentering equivalent to a given refracting angle (index of refraction,* 1.54).

	NO. OF PRISM.							
Lens . . .	1	2	3	4	5	6	8	10
	DECENTERING REQUIRED.							
1 D . . .	9.4	18.8	28.3	37.7	47.2	56.5	75.8	95.2
2 " . . .	4.7	9.4	14.1	18.8	23.6	28.2	37.9	47.6
3 " . . .	3.1	6.3	9.4	12.6	15.7	18.8	25.3	31.7
4 " . . .	2.3	4.7	7.1	9.4	11.8	14.1	18.9	23.8
5 " . . .	1.9	3.8	5.7	7.5	9.4	11.3	15.2	19
6 " . . .	1.6	3.1	4.7	6.3	7.9	9.4	12.6	15.9
7 " . . .	1.3	2.7	4	5.4	6.7	8.1	10.8	13.5
8 " . . .	1.2	2.3	3.5	4.7	5.9	7.1	9.5	11.9
9 " . . .	1	2.1	3.1	4.2	5.2	6.3	8.4	10.5
10 " . . .	.9	1.9	2.8	3.8	4.7	5.6	7.6	9.5

Reading glasses should be tilted forward and placed about 5 mm. lower down than those for distance, in order to conform with the depression of the visual line in reading. Spectacles are always to be preferred, and in high grades of astigmatism they are essential; but the prejudice of many patients in regard to spectacles will often have to be respected. When the astigmatism is not of high grade, and the individual has a sufficiently prominent nose, eye-glasses can easily be retained in place; but the tilting forwards of the glasses nearly always diminishes the acuity of vision for distance. This tilting is rather an advantage in reading glasses, and in myopia the effect of this tilting is equivalent to a cylindrical lens with a horizontal axis. This fact accounts for the preference shown by some patients for a simple concave spherical uncombined with a cylindrical lens, in spite of the existence of a slight degree of astigmatism.

When separate glasses are required for distance and reading, it is often very inconvenient to make the change from one to the other. The two glasses may be combined in the same frame by making the lower half suitable for reading, and the upper half for distant vision. Two segments of a spherical lens, ground very thin and cemented on the lower portion of the distance glasses, afford the means of reading and seeing distant objects through one pair of glasses. These are known as *bifocal lenses*. "Hook fronts" are very convenient for making a rapid change from reading to distant vision, and "half-hook fronts" are still better.

CHAPTER V.

DISEASES OF THE EYELIDS.

Congenital Anomalies.—Complete absence of the lids (*ablepharia totalis*), or their partial development (*ablepharia partialis*), is a rare anomaly. If the defect is of such a nature that the lids are wanting, and the orbit divested of any covering for the globe, the condition is designated *lagophthalmos*, a name which also, and perhaps more properly, has been given to a contracted state of the eyelids preventing their closure, independent of any muscular paralysis.

Cryptophthalmos is a condition in which neither eyelid nor conjunctival sac is present, but the exterior integument passes in front of, and buries an eye more or less developed.

Cleft eyelid (coloboma palpebræ) is a fissure, in appearance not unlike a hare-lip, which may be confined to the upper lid (its most common situation), but which also has been noted in the lower lids, and even in the upper and lower lids on each side. The centre of the cleft contains an intervening membranous portion, either movable or pressed against the cornea.

Coloboma of the eyelids is most frequently associated with hare-lip; rarely with other congenital anomalies in the eyeball. The deficiency may be remedied by a plastic operation.

Symblepharon or a cohesion, either partial or complete, between the eyelid and the ball, and *ankyloblepharon*, or a union between the margins of the lids, are unusual congenital anomalies. Sometimes only the middle portions of the lid-borders are attached; it may be by a filamentous band, or the outer angles of the lids adhere, and produce the defect known as *blepharophimosis*.

Ectropion, or eversion of the edges of the eyelids, is a rare condition usually accompanied by increased size of the eyeball. *Entropion*, or inversion of the edges of the lids, which in slight degree is said to be normal before birth, has been found

associated with *distichiasis*, or the development of supplementary incurved eyelashes.

The operations which are employed to rectify these conditions when of pathological origin (see page 579) are also applicable here.

Epicanthus is a striking congenital anomaly giving rise to an apparent convergent strabismus, owing to the passage of a fold of skin from the inner end of the brow to the side of the nose, covering the internal canthus, its free concave border stretching outwards. Thus the caruncle, lachrymal punctum, and in aggravated forms, a considerable portion of the area of the lids, are hidden. Epicanthus generally is bilateral and is usually associated with ptosis. The same condition in minor degrees is often seen in newborn children, and disappears with the subsequent development of the face and nose.

The defect may be remedied by excising a portion of the redundant integument from the bridge of the nose, and stitching together the opposed surfaces.

Congenital ptosis consists in a drooping of the upper lid over the eyeball. It may be single or double, but never amounts to complete closure. In one variety there is an actual redundancy of the lid tissue; in the other, the lid is thin and the skin stretched, owing to imperfect development or absence of the levator palpebræ.

This anomaly is often associated with other vices of conformation, especially epicanthus, and with paralysis of the external ocular muscles. It may be corrected by one of the operations described on page 577.

Erythema of Lids appears in the form of a hyperæmia, more or less diffused, under the influence of heat (sun-burn), traumatism, and irritating poisons, or as symptomatic of a systemic disturbance.

A *passive hyperæmia*, in which the superficial veins of the lids are dilated and the tissue red and slightly swollen, commonly is the result of prolonged bandaging of the eye, and is seen in an *active* state associated with most of the inflammatory diseases of the cornea and conjunctiva.

TREATMENT.—This consists in removal of the cause and the application of a soothing lotion, lead water or extract of hamamelis.

Erysipelas rarely attacks the eyelids as a primary affection, but spreads to them from the contiguous facial area. The chief danger of the affection in this region is its liability to infect the tissues of the orbit, producing compression of the central vessels of the retina, and consequent blindness. It may spread to the membranes of the brain and be fatal. The characteristic red, shining, and later brawny swelling, and the formation of cutaneous vesicles and small abscesses, are the symptoms which establish a diagnosis.

The *treatment*, both local and general, demands the same procedures which are applied to the disease when located elsewhere in the body.

Abscess of the Lid (*phlegmon*) appears as localized, red elevation, while the entire lid is hyperæmic and the conjunctiva injected, and often œdematous. There is much pain, headache, and fever. This affection is provoked by injury, exposure, and disease of the orbit, and sometimes arises without ascertainable cause, especially in debilitated people and children.

TREATMENT.—Pointing should be favored by a carefully adjusted poultice (one covering the entire eye should not be used), or hot, slightly carbolized fomentations. As soon as fluctuation is detected, or even earlier, a sharp knife may be thrust through the swelling, parallel to the muscle fibres, and the contents evacuated; the cavity is to be kept clean with an antiseptic fluid.

Furuncle of the Lid is a localized inflammation of the skin and subcutaneous tissue, presenting symptoms analogous to abscess, which goes on to the formation of a central slough or "core." The surrounding and overlying tissue may become gangrenous in subjects of poor nutrition.

Malignant pustule, or *specific anthrax*, caused by the entrance of the *bacillus anthracis*, and *malignant œdema*, or a form of *spreading gangrene*, are affections rarely seen upon the eyelids. The former usually arises among people whose occupation brings them in contact with diseased animals or decayed animal matter;

the latter may follow an injury, but has also been described as an idiopathic affection.

TREATMENT.—According to the condition present, this should include incision, promotion of the separation of the sloughs by poultices, the use of the actual cautery to check the destructive tendency, and antiseptic lotions.

Hordeolum or **Stye** is a small furuncle or boil in the margin of the lid, and consists of a localized, suppurating inflammation of the connective tissue, or of one of the glands at this point. This may remain as a tender, circumscribed swelling, which becomes invested with a yellow cap indicating suppuration, or it may cause considerable pain, with œdematous swelling of the entire lid and chemosis of the conjunctiva. Some people are subject to a mild type of styes which appear in the form of superficial pustules along the margin of the lid. A characteristic feature of hordeolum is its tendency to recur, and a single stye, or several at a time, may appear again and again for many weeks. Certain occupations, such as driving in the cold or dust, and the strain of uncorrected ametropia, predispose to this disorder. Frequent "attacks" of styes indicate derangement of health, and are especially associated with constipation and menstrual irregularities. Girls about the age of puberty are commonly affected.

TREATMENT.—A stye sometimes may be aborted by the vigorous application of a hot boracic acid lotion, or an ointment of the red or yellow oxide of mercury; the same end is obtained by painting the inflamed surface with collodion. In the event of failure, suppuration should be encouraged by repeated applications of small compresses steeped in hot water, and an incision should be made on the earliest appearance of pus by a knife thrust deeply through the base of the swelling, parallel to the edge of the lid.

Exanthematous Eruptions on the eyelid are found during the course of various of the eruptive fevers, but require no special comment except in the case of smallpox. In this disease, the pustules, if they appear upon the eyelids, form by preference at the commissures, and in connection with the follicles of the eyelashes. The subsequent pitting from loss of tissue may cause considerable disfigurement.

Sometimes a pustule declines to heal and forms a spot of chronic inflammation lasting for a long period of time, and known as a *post-variolous ulcer*.

Eczema of the Lids, independently of that variety which is located upon the ciliary margin and which is one of the forms of blepharitis, may appear upon the general cutaneous surface of these structures, usually in association with its presence elsewhere on the face and scalp, and is seen in the *erythematous*, *vesicular*, and *pustular* varieties.

Eczematous eruptions upon the lids are also associated with inflammations of the cornea and conjunctiva, and arise under the influence of prolonged bandaging. Atropine, when it produces conjunctivitis (see page 249), may cause an eczema of the lids and surrounding face.

Treatment.—This depends upon the character of the eruption. If this is vesicular, a useful application is a drying powder composed of starch, oxide of zinc, and camphor; if crusts have formed, these should be removed with as little bleeding as possible and with the aid of an alkaline solution, maceration of the epidermis being avoided, and one of the following ointments employed: Plain oxide of zinc, or equal parts of oxide of zinc and vaseline to which 20 grains of calomel have been added; or subnitrate of bismuth in an ointment. Itching is relieved by the application of *lotio nigra* followed by zinc ointment. If the disease assumes a chronic type, some preparation of tar (*pix liquida* or *oil of cade*) may be used. Good results follow the use of aristol ointment, both in subacute and chronic cases.

As constitutional remedies, quinine, iron, and strychnia are recommended, and arsenic, if the type is chronic. Proper regulation of diet, an occasional saline laxative, and good hygiene are important measures.

Herpes Zoster Ophthalmicus is an inflammatory disease, characterized by an eruption of vesicles, situated upon inflamed bases, over the area supplied by two of the three branches of the ophthalmic, or first division of the trigeminus, viz., the frontal through its supraorbital and supratrochlear branches, and more rarely the nasal nerve.

Neuralgic pain, heat, and redness of the skin precede the

vesicles, which, varying in size from a pin's head to a split pea, appear in distinct crops, or coalesce in irregular patches. At first they contain a clear yellow fluid, later becoming turbid, until at the end of a week or more they dry up, and the brown scabs drop off, leaving beneath decided and often disfiguring scars.

The disease may be mistaken for erysipelas, from which it should be distinguished by the acute neuralgic pain, and the formation of the vesicles in the course of a given set of nerves.

Serious involvement of the eye itself, by the formation of blebs upon the cornea, and by inflammation of the iris and ciliary body, is often associated with the disorder. More or less conjunctivitis is always present. The blebs on the cornea rupture and form ulcers, which leave permanent scars, and the iritis and cyclitis may eventuate in a destructive inflammation of the deeper coats of the eye (ophthalmitis). Atrophy of the optic nerves and paralysis of the oculo-motor have followed ophthalmic herpes.

Inflammation of the tissues of the eye is most apt to occur when the nasal branch is affected, and the vesicles extend to the tip of the nose, because from this branch, through the lenticular ganglion, arise the nerves supplying the iris, ciliary body, and choroid. This is not an invariable rule, and destructive disease of the eyeball may appear even when the nasal branch is not involved. A severe and most intractable neuralgia often remains after the subsidence of the eruption.

Herpes zoster ophthalmicus is more frequently seen among elderly people of feeble nutrition than among adults and young children, but the latter may be attacked even in the absence of constitutional depression.

Treatment.—The disease runs an acute course and tends to spontaneous recovery in two or three weeks. Locally, anodynes are useful—lead-water and laudanum, weak carbolic acid lotions, and preparations of belladonna. Severe pain must be mitigated by opiates, and morphia hypodermically, while the best constitutional remedies are full doses of quinine and iron, and later arsenic. The post-neuralgic pain may be relieved by croton chloral hydrate in doses of 5 to 10 grains every four hours, and by the use of a mild galvanic current. If conjunctivitis, kera-

titis, iritis, or cyclitis arises, this requires the treatment directed to the relief of such conditions, which is detailed in the special sections devoted to their consideration.

Blepharitis is the term applied to the various grades of subacute and chronic inflammation of the border of the eyelid, which for clinical purposes may be gathered into two groups—*non-ulcerative* and *ulcerative blepharitis*. The former may be studied under several subdivisions :—

(1) *Hyperæmia of the lid border* (hyperæmia marginalis, vasomotor blepharitis).—The margins of the lids have an unpleasant, slightly swollen, red appearance. Exposure to cold wind or any strain upon the accommodation causes a feeling of heat, followed by burning and lachrymation. The redness is caused by the passive congestion of the superficial bloodvessels, and the affection is unattended by the presence of scales or crusts, or these are but sparingly present.

(2) *Simple blepharitis* (seborrhœa of the lid border, blepharitis ciliaris, squamous blepharitis).—This variety depends upon an abnormal secretion of the sebaceous glands, and results in the formation of scales and crusts situated on the margin of the lids at the bases of the eyelashes, or adhering to them, and may appear either in a dry or a moist form. Removal of the hardened sebum exposes the skin, shining and red and occasionally abraded, a procedure associated with the loss of a few cilia. There is usually slight conjunctivitis. An accompanying seborrhœa of the eyebrows and scalp may be present; both lids are invariably affected, and the patients complain of burning, inability to perform close work, and some dread of light.

Exposure to cold and dust, and the use of the eyes, quickly increase the congestion of the lids. If the disease is of long duration, or is subject to frequent relapses, considerable thickening of the lid margins is evident, due to the inflammation surrounding the glands in the skin and tarsus.

The second, or *ulcerative* form of blepharitis appears in several grades of severity as a special localization of—

Eczema upon the lid border (blepharitis ciliaris, blepharitis ulcerosa, psorophthalmia, lippitudo ulcerosa, tinea tarsi, sycosis tarsi, ophthalmia tarsi, etc.).

a. Superficial form (marginal eczema).—This resembles in general that variety which has been described as hyperæmia of the ciliary margin, and causes the patient much annoyance through the possession of "weak eyes," from frequent attacks of redness and soreness of the borders of the lids, associated with the formation of crusts, small pustules and ulcers at the roots of the lashes, without, however, seriously interfering with their nutrition or growth.

b. Solitary form (blepharo-adenitis ciliaris, a name given by Arlt).—This is characterized by the appearance of a circumscribed area of thickening and redness of the lid margin, upon which the cilia are matted together at their bases by the formation of thick yellow crusts. A single tuft of this kind may be present, or several on one lid border; the process is frequently unilateral, in this respect, being unlike the squamous forms which are bilateral. Removal of the crusts evacuates a few drops of thin pus from the surface of the ulcer which lies beneath, and the cilia, which usually come away with the scab, have swollen and thickened roots. Spots of eczema at the nares and in the hair of the scalp may be present at the same time, as well as disease of the lachrymal passages.

c. Pustular form (blepharitis ciliaris ulcerosa).—This manifests itself as an eczema of lid margins, in its worst types involving the four ciliary borders. Thick yellow crusts, which mat the eyelashes, form along the palpebral margins, covering deep ulcers which readily bleed, and, often crater-shaped, pass inward to the tarsus.

The inflammatory process, if unchecked, seriously interferes with the nutrition of the lashes and the edges of the eyelid. The former become stunted, curled, misplaced (*trichiasis*), or drop out, and may be entirely wanting (*madarosis, tylosis*). The latter assume a rounded shape, are swollen, reddened, thickened, slightly everted, and deprived of cilia (*lippitudo* or "blear eye"), and if the punctum lachrymale is displaced or closed, an overflow of tears adds to the discomfort of the patient.

It is not always possible thus sharply to separate the various types of blepharitis, as they often shade one into the other; nor is it always safe to decide between those which arise from

glandular hypersecretion and those which are due to eczema. After the cure of an ulcerative variety, small scales may form resembling the simple or squamous type, while the latter may also lead to, or be associated with, ulcerations.

Etiology.—In the majority of instances blepharitis is a disease of childhood, and is common near the age of puberty ; the aggravated forms, especially those resulting in chronic changes in the ciliary margins, are frequently seen in adults as the result of neglect. The malady may follow in the wake of an exanthem, particularly measles, and finds many subjects among children of strumous habit, with blonde hair and pale complexion. The usual presence of considerable degrees of ametropia has led to the belief that this causes blepharitis (Roosa). There is no doubt that it aggravates and fosters the condition.

Of considerable importance in the origin of this affection are inflammations of the tear-sac, stricture of the nasal duct, and obstructive disease of the posterior nares, although it may be difficult in individual cases to decide whether the blepharitis has caused the closure of the lachrymal passages, or whether this has developed the blepharitis. Finally, some instances appear to arise from an abnormal shortness of the lids resulting in their insufficient closure during sleep (Fuchs).

Staphylococci have been found in the pustules at the roots of the lashes ; but these probably indicate only the presence of the pus, and do not act as causative agents.

Treatment.—This differs with the type of the disease, but in all cases the refraction of the eye should be ascertained and any anomalous condition corrected with suitable glasses. This will often cure an ordinary hyperæmia of the lid margin, but if it is not sufficient, in addition to soothing lotions, the daily use of an eye-douche is most serviceable, performed as follows :—

A suitable vessel, to which is attached a rubber tube having at the lower end a small tin arrangement, containing many perforations like the rose of a watering-can, is filled with water of a temperature of 68° F., and held a short distance above the head, the water being allowed to play for several minutes upon the closed eyelids. The douche may be made more acceptable by the addition of a little *eau de cologne*, or alcohol. This method, recom-

mended by Koenigstein, is most efficacious. Stimulating salves do not yield good results in this variety, but the edges of the lids may be anointed with almond oil or vaseline.

In the cases classified among the seborrhœas, all crusts and scales should be removed by alkaline solutions (bicarbonate or biborate of soda, grs. viij–f℥j), or with a 5 per cent. solution of chloral (Gradle), and one of the following ointments applied once or twice daily: yellow oxide of mercury (gr. j–℥j), zinc ointment, or the salve advised by Gradle:—

Milk of sulphur	3 grains
Resorcin	3 grains
Vaseline	100 grains

Great care must be exercised to remove the crusts from all the ulcerated varieties, either with the lotions which have been mentioned, or, after softening, with forceps, before the application of any salve. Red or yellow oxide of mercury, or dilute citrine ointment, is suitable.

In chronic cases, all loose cilia should be extracted with epilating forceps, and any deep ulcers should be touched with the point of a crayon of nitrate of silver, or pencilled with a solution of the same drug. In severe forms, or where it is desirable to try other remedies, the following formulæ will be found useful:—

Diachylon ointment	15 grains
Vaseline	240 grains

Boracic acid	30 grains
Simple ointment	300 grains

Aristol	15 grains
Vaseline, Lanolin } of each	75 grains.

If the lachrymal passages are obstructed, these must be rendered patulous, and in all cases the posterior nares should be explored for disease.

The constitutional remedies include iron, quinine, and, if struma is present, cod-liver oil and lacto-phosphate of lime, with iodide of iron or syrup of hydriodic acid.

Blepharitis may be a mild affection and yield readily to treat-

ment; or it may be stubborn, and require constant attention and frequent change in local measures to prevent deformities in the lid margins.

Phthiriasis (blepharitis pediculosa) occurs when the pediculus pubis or crab-louse forsakes its seat of predilection and finds a habitat among the eyelashes. The cilia appear sprinkled with a fine dark powder—the eggs of the parasites—which are usually found partially buried, head foremost, in the hair follicles. There is some itching and redness. The affection is comparatively rare, and in most instances has been observed in children. The lice may be removed by the application of blue ointment, or a careful pencilling with a strong bichloride solution.

A parasite which in rare instances has been found in the hair follicles of the eyelids (Steida) and in the Meibomian glands (Majocchi) is the *Demodex folliculorum*. In one case the symptoms resembled those of blepharo-adenitis. Removal of the parasite resulted in cure.

Syphilis of the Eyelids.—Syphilitic affections of the eyelids exist either as the primary sore, or as secondary or hereditary manifestations. A chancre usually appears on the area included by the lid borders and inner canthus, the tarsal conjunctiva and the cul-de-sacs. (DeBeck.) The lesion begins as a pimple which gradually develops into a characteristic, somewhat saucer-shaped ulceration, with rather rounded edges and indurated base. The lymph glands in front of the ear and at the angle of the jaw are enlarged. Contagion has often occurred by the application of the lips or tongue of an individual suffering from mucous patches in the mouth, as, for instance, in the act of kissing; or by the filthy practice of attempting to remove a foreign body with the tip of the tongue. Soiled fingers have also carried the contagion.

It is possible to mistake the affection for a stye, suppurating chalazion, ulcerated tear-sac, or a rodent ulcer of small size.

Treatment.—Locally, the ulcer may be dressed with black or yellow wash. As soon as positive secondary manifestations are sufficiently evident to settle the diagnosis, the ordinary anti-syphilitic remedies should be exhibited.

The lesions of *secondary syphilis* upon the eyelids require no special description.

Among the later manifestations *gummata* of the skin of the lid, which break down into ulcers—so-called *tertiary ulcers*—are described.

A papular eruption may appear upon the eyelids of children, the subjects of hereditary syphilis, shortly after birth. A form of blepharitis, characterized by sharply ulcerated spots, has been described as the result of hereditary syphilis, and in subjects of this dyscrasia, absence and falling-out of the eyelashes have been seen. The latter condition also arises during secondary syphilis.

Tumors and Hypertrophies.—A variety of growths, cystic and solid, are found upon the eyelid and its border. Along the latter, *warts* or *papillomata* are common. These are benign, except when in elderly people through irritation they may take on an epitheliomatous nature. They should be cut off and their bases should be cauterized.

Small clear *cysts* are common along the ciliary margin, often giving rise to considerable irritation. They should be punctured.

A reddish, wart-like mass may occur at the mouth of a Meibomian gland-duct. This is to be treated like an ordinary wart.

Angiomas (*Naevi*) are congenital growths, and exist either as bright red spots, or in the form of elevated cavernous growths. They should be dealt with early in their existence, lest they spread into the orbit.

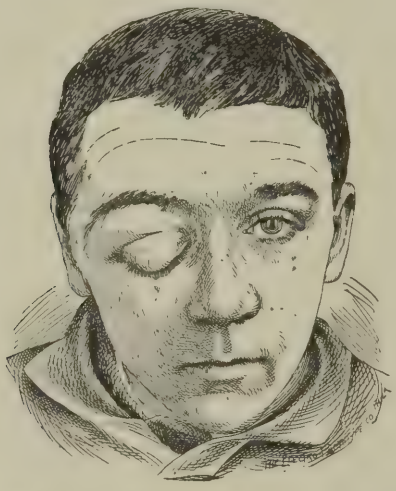
That operative interference should be practised which promises the least subsequent deformity to the lid. When small, they may be excised, or cauterized with nitric acid; if of a larger variety, their bloodvessel structure should be destroyed with the galvanocautery or red-hot needles. Injections of liquor ferri subsulphatis are not to be recommended.

Cutaneous corns (*fibroma; molluscum fibrosum*).—These occur as connective-tissue new growths, either sessile or pedunculated, sometimes associated with numerous similar tumors elsewhere on the body.

Neuromas, of the plexiform variety, and *lipomas* are benign growths which should be removed by careful dissection under

antiseptic precautions. The latter growth sometimes appears in the form of an extensive accumulation of fat in the connective tissue of the lid, causing it to droop over the cornea, and produces the condition to which the name *ptosis lipomatosis* has been given. The mass should be dissected out, but complete mobility of the lid is not always regained, owing to failure in the power of the levator palpebræ.

Fig. 74.



Congenital ptosis due to a hypertrophic condition of the skin of the eyelid, and tumor formation.

Rare forms of benign tumors are *adenoma* of the sweat-glands and their follicles, *papilloma* of the ciliary border, and *enchondroma* of the tarsus.

Xanthelasma (*xanthoma*) is a connective-tissue new growth, with fatty degeneration, usually seen in the form of narrow, semicircular patches, most common upon the upper eyelids, although all four lids may be affected. The patches are yellow or buff-colored, and on a level with the surrounding skin, or slightly raised above it.

Excision, if this may be performed without producing ectropion, is the simplest method of treatment. The growth produces no irritation.

Chalazion (*Meibomian cyst, tarsal tumor*).—This is a small tumor or retention cyst, due to a chronic inflammation of a Meibomian gland and the tissue which surrounds it. The growth begins by retention of the secretion of the Meibomian glands, followed by a peri-adenitis and destruction of the tarsal cartilage, with passage of the tumor towards the conjunctiva (*internal chalazion*), or to the skin (*external chalazion*). According to the rapidity of its development, the chalazion is either *acute* or *chronic*.

Cause.—The cause of chalazia is not known. They may be associated with inflammation of the border of the lid and stoppage of the duct of the gland. Individuals affected with these growths not infrequently have ametropic eyes, especially when there is a tendency to recurrence in crops, like styes. They are more common in adolescence than in youth, childhood, or in old age. Bacteria have been described, but they exist only in connection with suppuration in the cyst.

Symptoms.—The tumor grows slowly, unless it is of the acute type, and forms a firm swelling attached to the tarsus. The skin usually is freely movable over it; on the conjunctival surface a discolored patch marks its position. Suppuration may take place in the cyst.

An acute chalazion may be mistaken for a stye, from which it is to be distinguished by the more circumscribed character of the inflammation, and by the fact that the stye points in the edge of the lid; and a chronic chalazion for a sebaceous cyst, from which it may be differentiated by the firmness of its attachment to the tarsus. Chalazia and small sarcomata of the lid have been confounded.

Treatment.—It is sometimes attempted to produce resolution by the inunction over the swelling of a resolvent ointment. The following may be tried:—

Yellow oxide of mercury	2 grains.
Vaseline, Lanolin } of each	30 grains.

Or—

Iodide of cadmium	10 grains.
Vaseline	60 grains.

The skin should first be prepared by frequent applications of hot water.

The only radical measure is removal by means of an incision, according to the method described on page 576.

The malignant growths which appear upon the eyelids are *sarcoma, carcinoma,* in the form of *epithelioma* or *rodent ulcer,* and *lupus.*

Sarcoma occurs as a primary tumor in both upper and lower lids, and usually is seen in children. At first the growth is slightly elastic and the skin moves over it freely, but the tendency is to rapid growth, ulceration, and involvement of the orbit. The various types of sarcoma have been seen in this region, and the tumor has been known to follow a contusion.

An early removal of the growth is urgently indicated, but even then local return or metastasis may follow.

Carcinoma of the eyelid generally appears in the form of *rodent ulcer* (Jacob's ulcer), which is a type of epithelial cancer, characterized by slow ulceration and non-involvement of the neighboring lymph-glands, and is usually seen in elderly people.

The growth begins as a pimple over which a crust appears. Gradually an ulcer forms, which slowly spreads with indurated and elevated edges, and if unchecked involves all the tissues and destroys the eyeball. Often many years elapse before the ulcer attains any considerable size. The most common point of origin is the inner end of the lower lid.

The slow growth, and absence of lymphatic involvement, together with the age of the patient, suffice to distinguish rodent ulcer from a tertiary syphilitic sore.

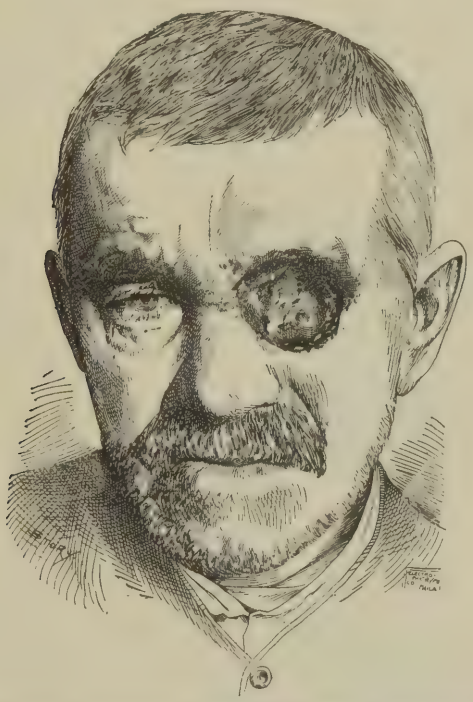
It may be confounded with lupus; but the latter occurs in younger subjects, is more inflamed and less indurated, the ulcerations proceed from many points, and are generally associated with lupus elsewhere in the body.

Instead of rodent cancer, an epithelioma with the ordinary clinical characteristics may attack the eyelid. *Glandular carcinoma,* having its point of origin either in the Meibomian or in Krause's glands, is a rare form of cancer.

Treatment.—Certain local remedies, like aristol, have been recommended, but the only proper treatment is excision. This must be undertaken at as early a date as possible, in order to prevent the necessity of extensive plastic surgery to replace the

excised tissues. If the disease is advanced, it may be necessary to employ Canquoin's paste, scraping, or the actual cautery, and in this way much can be done to resist the progress of the ulceration.

Fig. 75.



Destruction of eyeball by a rodent ulcer which began in the lid sixteen years ago. From a patient in the Philadelphia Hospital.

Lupus Vulgaris is a cellular new growth composed of variously-shaped, reddish tubercles, which usually terminate in ulceration and extensive cicatrization. As this disease commonly appears on the face, it may also involve the eyelids.

The process begins in youth, often before puberty, and is slow in its course. The ulcers are apt to start from a number of points which coalesce; their edges are soft, and the discharge is offensive. *Syphilitic ulcers*, on the other hand, are deeper, more excavated, with harder margins, and their course is more rapid.

Treatment.—Local application of caustic paste, erasion with a curette, and the actual cautery have been employed, and, recently, injections of tuberculin.

Lepra.—Leprosy attacks the eyelids very frequently. According to Lopez two-thirds of the patients suffer from lesions in this region. These consist of anæsthetic patches of color slightly different from that of the surrounding integument, tubercles, loss of the eyelashes and eyebrows, and ectropion and entropion, the former occurring with extraordinary frequency.

Fig. 76.



From a photograph of a patient with syphilitic tarsitis, under the care of Dr. Randall in the Children's Hospital.

Elephantiasis Arabum, or a chronic hypertrophic disease of the skin and subcutaneous tissue, has appeared in the upper eyelid in consequence of an injury, but may also be congenital. *Elephantiasis teleangiectodes,* or that disease which consists in a

hypertrophy of the skin and connective tissue, together with fatty tissue and distended vessels, occurs in the upper eyelid as a congenital affection.

Tarsitis, or inflammation of the tarsus, is usually syphilitic in origin, and presents great thickening of the tarsus, owing to diffuse gummatous infiltrations. As a rule, it is chronic in course; in rare instances, an acute form has been described. As an idiopathic affection, the disease resembles a chronic marginal blepharitis, with the formation of crusts and ulcers at the mouths of the hair follicles, but differs from the latter condition by the presence of considerable thickening and induration of the tarsus.

Treatment.—If syphilitic, tarsitis is amenable to the ordinary remedies; if idiopathic, much the same treatment described in connection with chronic blepharitis is applicable, especially the use of resolvent ointments.

Blepharospasm, or an involuntary contraction of a portion or of the whole of the orbicularis palpebrarum, appears either as a *clonic* or a *tonic* cramp.

The former variety, in its simplest forms, consists in a twitching of a few fibres of the muscle, most commonly in the lower lid, very annoying, and often the cause of undue alarm. It arises from the strain of uncorrected ametropia, prolonged eye use, and deficient amplitude of accommodation.

The *treatment* comprises the prescription of glasses, and a general tonic, a very suitable one being an elixir of quinine, iron and strychnia, provided the last remedy does not aggravate the affection, in which case it may be omitted from the combination. In stubborn cases, fluid extract of gelsemium will afford relief. Conium internally, and the extract locally, have been recommended.

Children are often affected, especially during their early school years, with undue winking of the eyelids, associated, at times, with jerky movements of the facial and other muscles. This form of nervous disorder is designated by Weir Mitchell "*habit chorea*."[1] Almost invariably blepharitis, follicular conjunctivitis, and errors of refraction and insufficiencies of the external eye

[1] Gowers gives the name "habit spasm" to the same affection.

muscles will be found as exciting causes. Suitable glasses and appropriate local remedies, together with the exhibition of Fowler's solution, will usually bring about a cure.

Tonic cramp of the orbicularis follows the introduction of foreign bodies into the eye, the presence of inflammations of the cornea and conjunctiva, and fissures at the angles of the lids.

More rarely, a persistent lid cramp occurs, without obvious cause, and is unrelieved for weeks and even months. When the eyes are finally opened there may be temporary blindness, without corresponding ophthalmoscopic changes; or permanent loss of vision, with gross lesions in the eye-ground.

Tonic cramp appears to be a form of reflex action, arising through irritation of the peripheral trigeminal filaments. The blindness which has been observed in certain instances has been explained as cortical in nature, owing to the long absence of peripheral stimulation, or as an example of the "forgetting volition" of the sensory perceptions, analogous to the suppression of the image in alternating strabismus. (Samelsohn.) If gross changes appear, these have been explained by pressure of the closed lids upon the ball.

The *treatment* demands the removal of any peripherally exciting cause—fissure, foreign bodies, phlyctenules, etc. Hypodermics of morphia have been used to control the trigeminal irritation, and in bad cases section of the supraorbital nerve has been performed. Conium and gelsemium in the form of the fluid extract may be tried. They should be pushed to the point of tolerance.

Ptosis (*blepharoptosis*) is that condition in which the upper lid droops entirely or partially over the eyeball, and cannot be voluntarily raised. It is either congenital (page 189), or acquired by reason of the development of fatty or other accumulations in the connective tissue of the lid (page 200), or it arises from paralysis of the entire oculo-motor nerve. In rare instances, ptosis (monolateral in character) occurs from lesion of the cortical centre for this branch of the third nerve. (For farther discussion of ptosis see Ocular Palsies.)

Treatment.—The medical treatment calls for the exhibition of those remedies which control the supposed cause of the palsy—mercury and iodides in syphilis, salicylic acid in rheumatism. The surgical treatment will be found on page 577.

Lagophthalmos, or an inability to close the eyelids, is either paralytic or non-paralytic, and usually results from paralysis of the facial nerve, as in Bell's palsy, but also occurs in tumors of the orbit, exophthalmic goitre, and staphyloma. The highest grade of lagophthalmos appears as a congenital defect (page 188).

The chief danger of the affection is ulceration of the cornea from exposure, rendered all the more certain should disease of the trigeminus also exist.

Treatment.—In paralytic lagophthalmos the primary cause of the affection must be treated; in the non-paralytic varieties, and in any form in which the vitality of the cornea is threatened by its exposure, the operation of tarsorrhaphy may be employed. (See page 578.)

Symblepharon,[1] or a cohesion between the eyelid and the ball, may be complete or partial, acquired or congenital (page 188). The most usual causes are injuries, especially burns with acids or lime. Symblepharon also follows diphtheritic conjunctivitis, trachoma, pemphigus, and occasionally purulent ophthalmia; but the shortening of the conjunctival sulcus, which occurs by a species of drying of the conjunctiva, presently described, must not be confounded with a true symblepharon. The attachment may be merely slight bands between the conjunctival surface of the lid and ball, or, in the more complete cases, the cornea may also be involved in the cicatricial union, and vision seriously disturbed. The lower lid is most usually involved in the process; the upper may also participate. (Fig. 77.)

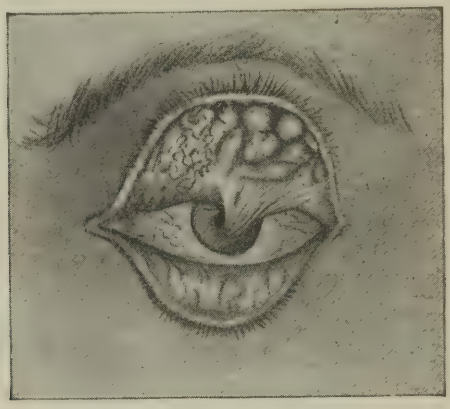
Ankyloblepharon, or that condition in which the borders of the two lids have grown together, may be congenital or acquired, and, like the preceding affection, partial or complete.

The same causes which originate symblepharon are here active,

[1] Symblepharon really belongs to diseases of the conjunctiva, but is conveniently inserted in this place.

and varieties are described in which the union takes place, not by a growing together of the lids, but by the organization of a membrane, the result of croupous conjunctivitis.

Fig. 77.



Symblepharon, the sequel of purulent ophthalmia. From a patient in the Philadelphia Hospital.

Blepharo-phimosis is the name given to that condition which arises through a contraction of the outer commissure of the lids, and results in shortening of the palpebral fissure.

It is commonly seen in cases of long-standing conjunctivitis with irritating secretions; for instance, in chronic blennorrhœa, and in some of the forms of granular lids.

Treatment.—After an injury, or during the course of a local disease, likely to result in one of these complications, scrupulous care must be exercised to avoid it. The formation of granulation tissue may be broken up with a probe, and it has been advised to place a piece of gold-beater's skin between the lid and the ball to prevent adhesions. It is doubtful if the latter expedient will often prove successful.

The surgical treatment of these affections is described on page 585.

Trichiasis; Distichiasis.—*Trichiasis* is that affection in which the lashes are misplaced and turn inward against the eyeball;

distichiasis, is that condition in which incurved rows of supplementary cilia are developed from the intermarginal part, close to the opening of the tarsal glands.

The most usual causes of trichiasis are chronic inflammations of the lid borders—blepharitis, and granular ophthalmia. Distichiasis, in rare instances, is congenital, or develops about the age of puberty, but occurs also as the result of the diseases named.[1] The cilia rubbing against the cornea produce constant irritation, and may lead to ulceration.

TREATMENT.—If not too numerous, the lashes having a faulty direction should be removed with cilium forceps, and when they grow again, the procedure repeated; their reappearance may sometimes be prevented by destruction of the hair follicles by galvanopuncture. Other operations consist of strangulation of the roots of the incurved lashes by a subcutaneous ligature, excision, and the various modifications of single and double transplantation of the entire ciliary border. (See OPERATION Chapter.)

Entropion, or inversion of the lid, like the former affection, is most commonly caused in an *organic* form by granular lids, and also follows essential shrinking of the conjunctiva and diphtheritic ophthalmia. Entropion and trichiasis are often associated.

Two other varieties of entropion are described, *muscular* and *bulbar*. The former is sometimes present at birth from undue development of the orbicularis, and also occurs in a spasmodic type, under the influence of conjunctivitis, keratitis, and foreign bodies; the latter is a falling in of the lids when the eyeball is shrunken or absent.

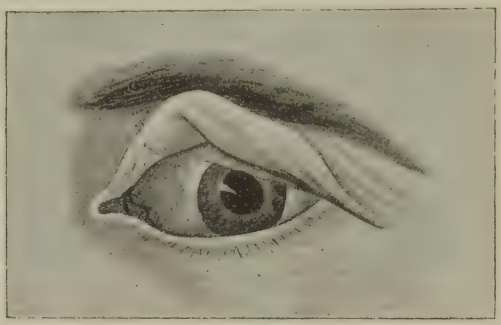
TREATMENT.—The spasmodic varieties will usually subside if the exciting cause can be removed. Painting the lid with flexible collodion, which by its contraction draws out the inverted border, or fastening this with a strip of adhesive plaster, or pinching up a longitudinal fold of skin and muscle with a *serre-fine* and keeping it in place, occasionally changing the position of the instrument to avoid irritation, are methods advocated

[1] Raehlmann believes that trichiasis hairs, or "false cilia," are developed from the epithelial covering of the lid margin in consequence of marginal blepharitis, the result of granular conjunctivitis.

in the treatment of temporary entropion. The organic varieties of the disorder require one or other of the operations described on page 581.

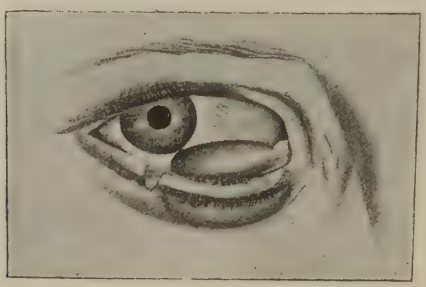
Ectropion, or eversion of the lid with exposure of the conjunctival surface, is either partial or complete. The disorder is divided into the *acute* or *muscular*, and the *chronic* form, or that which results from organic changes.

Fig. 78.



Ectropion of the upper lid, the result of an injury to the brow and subsequent caries of the margin of the orbit. From a patient in the Philadelphia Hospital.

Fig. 79.



Ectropion of the lower lid, the result of a wound from the tine of a fork. From a patient in the Children's Hospital.

Acute ectropion usually occurs in children with ophthalmia, and in diseases of the cornea with blepharospasm, when the lids, during examination, become everted and remain so until

replaced. One form of partial muscular ectropion is produced by facial palsy.

The common causes of the second, or chronic form of ectropion, are wounds, especially such as are caused by dog-bites, by laceration of the lid by a sharp instrument, by burns and subsequent cicatricial contraction, by chronic inflammatory conditions of the ciliary margin, by ulceration of the lids as in lupus, and by caries of the orbital border and malar bone. The lower lid is more frequently involved than the upper, but ectropion is also seen in the latter.

TREATMENT.—This varies with the type and degree of the ectropion. In the spasmodic forms, simple replacement of the everted lids suffices; in slightly marked grades, with some eversion of the lachrymal punctum, the canaliculus should be slit, and, if necessary, the nasal duct should be probed. The organic types of the disorder require a plastic operation for the relief of the deformity. (See OPERATION Chapter.)

Certain diseases of the eyelids are comprised in a group of functional disorders of the sebaceous and sweat glands.

Seborrhœa, or that functional disorder of the sebaceous glands during which their secretion is altered, and forms an oily coating on the skin, sometimes accompanied with crusts and epithelial scales, is also seen upon the eyelids. It is usually associated with a similar process in the scalp and eyebrow, and when specially localized upon the ciliary margins, creates one of the forms of blepharitis already described.

TREATMENT.—Proper hygiene, cod-liver oil, iron and arsenic, removal of the accumulated sebum by frequent washings, and the application of sulphur and mercurial ointments comprise the most efficient methods of treatment.

Milium.—Milia, or small yellowish elevations, consisting of an accumulation of sebum within the distended but closed sebaceous glands, are common upon the eyelids. They often develop about the age of puberty.

They are caused by improper care of the skin, and may be connected with general constitutional disturbances, dyspepsia and constipation. They should be opened with a knife or needle, and the contents evacuated.

Molluscum contagiosum (*M. sebaceum*) is a disease of the sebaceous glands (according to some authors, of the rete mucosum), characterized by the appearance of rounded papules, about the size of a pea, and of a waxy color. The eyelids are a favorite situation.

The disorder occurs chiefly among ill-nourished children, is believed by many to be contagious, and may arise as an epidemic in homes and asylums. Recent investigations seem to show that the affection is caused by a parasite belonging to the class *coccidia*, and really is a form of contagious epithelioma.

TREATMENT.—Each molluscum should be incised, and its contents forced out.

Ephidrosis (*hyperidrosis*), or an increased flow of sweat, has in rare instances been observed as a local disorder of the sweat-glands of the eyelids. In cases of unilateral sweating of the face, the lids necessarily participate.

Chromidrosis, or the formation of a variously colored secretion from functionally disordered sweat-glands, is sometimes located upon the eyelids. It then receives the name of *palpebral chromidrosis*, and consists of a bluish-black discoloration, usually upon the lower lid, which is somewhat oleaginous and can be wiped away.

It is probably genuine in rare instances; in others, it is believed to be either a fraud practised by hysterical subjects, or due to the deposit of dust upon the surface of the skin affected with seborrhœa. Young women have usually been those affected with this disorder.

The *treatment* should consist in general invigorating methods calculated to remove anæmia, debility or nervous disturbances. Locally, lead water and glycerin are recommended.

Sebaceous Cysts occur in the eyelids, most frequently in the outer part, and also in the eyebrow. In the latter situation, they sometimes are deeply seated, tightly adherent to the periosteum, and may extend some distance into the orbit. Their removal by an ordinary dissection is usually unattended with difficulty.

Injuries of the Eyelids.—Incised, lacerated, and contused wounds, œdema, emphysema, and ecchymosis are the ordinary results of accidents and injuries to the eyelids.

Wounds.—The type of a wound depends largely upon the character of the implement which has inflicted it, and may vary from a simple and superficial incision to a deep cut which penetrates the tissues of the lid, and injures the structures of the eyeball lying beneath. In like manner, a laceration may be small and unimportant, or may be so extensive as to tear the eyelid from its attachments. Wounds inflicted by an incision in the line of the direction of the fibres of the orbicularis result in the least visible scar, owing to the absence of gaping.

Treatment.—Accurate approximation of the wound should be secured with catgut or silk sutures, and scrupulous antisepsis should be followed. Even considerable laceration may heal with very little deformity if neat adjustment is secured.

Œdema usually occurs as the sequel of a blow, owing to the loose connective tissue of the eyelids, which readily admits of distension.

Œdema not the result of an injury, is seen in association with severe inflammations of the conjunctiva, as part of a general condition (renal or cardiac), and sometimes in a fugitive and not infrequently recurrent form. The last variety has been observed with migraine, at the time of the establishment of menstruation, and spontaneously, without apparent cause. Some of the instances seem to be analogous to urticaria.

Treatment.—The application of evaporating lotions, like dilute lead-water and laudanum, associated, if the swelling is great, with a pressure bandage, is a measure which will afford relief. If a general cause is at the root of the trouble, this must receive appropriate treatment.

Emphysema of the lids is observed when a fracture of the orbit permits air to escape into the cellular tissue, through a communication thus produced with the ethmoidal or frontal sinus. A soft swelling, crackling to the touch, is the result, which increases in degree when the patient blows his nose and forces the air through the fissured bone. The eyelids may participate in the emphysema of the neck and face, sometimes seen after tracheotomy, or after stab-wounds of the chest.

Ecchymosis of the lids, or a collection of blood in the connective tissue, in its simplest variety constitutes the familiar "black eye,"

the common result of a blow. A gradual absorption of the effused blood takes place, requiring a week or longer for its completion, but the skin may retain its black and blue stain for a greater period of time.

Ecchymosis results also in some cases of fracture of the base of the skull, and may be associated with emphysema, if a fracture has involved the frontal or ethmoidal cells.

TREATMENT.—Emphysema will gradually subside without local treatment; if the swelling is severe, it has been recommended to prick the tissues and allow the air to escape.

Ecchymosis should be treated with frequent applications of cold water, arnica, lead-water and laudanum, or diluted white extract of hamamelis. If discoloration remains for a long time, the "eye may be painted." The practice of applying leeches, or incising the swollen lid and sucking out the contained blood, is to be deprecated.

Burns of the Eyelids are commonly inflicted with hot water, caustics (lye and lime), acids, or by the explosion of powder.

The first agent produces the ordinary vesication, and the treatment should consist in the application of oil, while the pain may be materially relieved by using locally a lotion of carbonate of soda, or, better, the moistened powder itself.

Burns caused by the other materials are especially dangerous on account of the almost invariable involvement of the cornea and conjunctiva. (See page 257.) Immediately after a powder burn, all loose powder should be removed, and if possible each grain picked out of the skin with a fine needle. The application for ordinary burns may then be used.

CHAPTER VI.

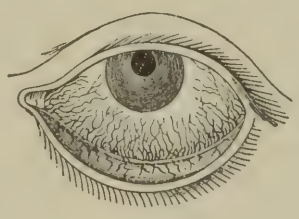
DISEASES OF THE CONJUNCTIVA.

Congenital Anomalies of the Conjunctiva.—In addition to dermoid tumors (page 253) certain thickenings of the conjunctiva, of congenital origin, have been reported. The latter resemble pterygia, and extend between the fissures of the lid. If necessary, excision could be performed.

Hyperæmia of the Conjunctiva (*Dry catarrh; Hyperæmia palpebraris*) is characterized by an injection of the vessels, chiefly of the palpebral conjunctiva, but rarely affecting the ocular expansion of the membrane. The posterior conjunctival vessels (System I.) are involved, but not to the same extent that they are in an ophthalmia. Both an acute and chronic form exist.

Causes.—The strain of uncorrected ametropia furnishes a large contingent of these cases, while others arise when the refraction error is insufficiently or improperly corrected. Beginning presbyopia, especially in those people who are disinclined to use glasses, and hyperæmia of the conjunctiva are often associated; it also occurs with incipient cataract and slight opacities of the cornea, as the result of the effort to obtain clear images.

Fig. 80.



Congestion of the posterior conjunctival vessels. (Guthrie.)

Local irritants like dust, foreign bodies, tobacco smoke, cold winds, etc. are common causes, and the abuse of alcohol originates many cases.

Nasal catarrh, lachrymal obstruction and marginal blepharitis are frequently accompanied by chronic hyperæmia of the conjunc-

tiva, which is much aggravated by the establishment of an acute coryza, or a condition like "hay fever."

Finally, certain acute hyperæmias, which may be recurrent, appear in the form of vaso-motor disturbances, and are seen under the influence of general diseases, especially gout.

Symptoms.—Direct inspection reveals the congestion of the vessels, not sufficient to produce the velvety appearance seen in ophthalmia, and unaccompanied by any discharge. Slight swelling of the conjunctival follicles may be present. There are photophobia, some lachrymation, a hot, stinging sensation, aggravated by use of the eyes, which readily "water" and grow uncomfortable, especially by artificial light.

Treatment.—This calls for the correction of any refractive error and careful examination into the accuracy of glasses, provided they are worn by the affected individual.

Removal of exciting local causes, and attention to the posterior nares are necessary. Patency of the canaliculi and of the lachrymal passages should be secured.

Locally, boric acid (gr. x–f℥j), or biborate of soda gr. v, camphor water f℥j and distilled water f℥j, may be applied. More active astringents like alum, tannin, and zinc are sometimes employed, and stimulating drops, as equal parts of tincture of opium and water, or boric acid solution, to which a few minims of alcohol have been added, are useful. Nitrate of silver is not advisable. Douching the eyes with hot or cold water is a valuable adjuvant.

If there is reason to suspect any general trouble, like gout, this must receive attention, and in those varieties believed to be of vaso-motor origin a mixture of tincture of nux vomica and fluid extract of ergot may be exhibited.

Ophthalmia.—The conjunctiva is liable to various grades and types of *inflammation* which have certain symptoms in common: (1) Photophobia, not constantly present in all varieties, but commonly seen at some time during the course of the complaint; (2) increased and usually altered secretion; (3) a changed appearance in the membrane, varying from a general injection of the blood-vessels, and slight velvety opacity, to the development of special pathological products, or the formation of false membrane.

The generic term "*conjunctivitis*," or "*ophthalmia*," is applicable to this entire group of diseases.

Simple Ophthalmia (*Catarrhal, Acute, or Muco-purulent Conjunctivitis, or Ophthalmia*). This is an inflammatory disease of the conjunctiva characterized by congestion, loss in the transparency of the palpebral conjunctiva, some dread of light and spasm of the lids, and a discharge sufficient only to glue the lids in the morning, or free and muco-purulent.

Causes.—The disease is commonest in warm and changeable weather, and, if the secretion is free, it is markedly contagious, and the affection will pass rapidly from one member of a household to another. Micro-organisms are present in severe types and may explain the contagion; neglected hyperæmias and the presence of follicular granulations increase the susceptibility to infection, and scrofulous subjects are peculiarly liable to the disease.

The etiology is further made evident by observing certain varieties:

Associated ophthalmias are seen with eczema, facial erysipelas, impetigo contagiosa, nasal catarrh, bronchitis, and constitutional disorders like typhoid fever and rheumatism. Among these may also be included the *exanthematous ophthalmias*, or those which accompany or follow certain of the exanthemata—measles, scarlet fever, and smallpox.

Mechanical ophthalmias result from exposure to wind, dust, and traumatism.

Symptomatic ophthalmias may arise from the strain of uncorrected ametropia, and are analogous to ordinary hyperæmias.

Finally, there are certain *special ophthalmias*, known as *epidemic conjunctival catarrh*, or *catarrh with swelling*, where the process is more particularly located upon the retrotarsal folds, in which group may be included that form vulgarly known as "pink eye," and commonly seen in the spring and fall, and supposed by some to be due to a special bacillus.

Symptoms.—The secretion is at first watery and by running over the edge of the lids may excoriate the surrounding skin, which shows injection of its superficial veins. In certain individuals the lids, especially along their palpebral margins, are slightly œdematous.

The secretion soon becomes mucous or muco-purulent, and, according to the grade of the inflammation, gathers in a slightly frothy material only at the commissural angles, or is very freely secreted, and when it dries, glues the borders of the lids and mats the cilia together.

Inspection of the retrotarsal folds may reveal the presence of long strings of mucus or muco-pus. There are a general hyperæmia and loss in the transparency of the tarsal conjunctiva, in which the posterior conjunctival vessels (System I.) are concerned, and later of the fornix, caruncle, and semilunar folds.

In severe types the entire conjunctiva is deeply injected, and small hemorrhages may be observed, the swelling of the membrane being noticeable in opaque, velvety layers, especially in the region of the retrotarsal folds, while the bulbar conjunctiva is chemotic. The lids are glued together in the morning, the eyes are hot and heavy, and feel as though they contained sand.

Although vision is not usually affected, some secretion may be adherent to the cornea and produce the same haziness in sight that would be present on looking through a dirty glass; and artificial lights, which are most uncomfortable at all times, appear fringed with colored borders.

Photophobia may be entirely absent, or exist in marked degree, most often in those varieties which complicate measles, or are associated with the development of small superficial ulcers on the cornea. All ages of life are liable to catarrhal conjunctivitis, but the majority of cases are seen in children and young people.

Prognosis and Duration.—The prognosis is perfectly good, and the process will usually subside in from one to two weeks. Commonly both eyes are affected, the one a few days in advance of its fellow. The affection through neglect, however, may prove exceedingly troublesome, and in the epidemic varieties, tends to attack all members of a household, a fact which in asylums and similar institutions may prove of serious import, especially if the severe types, not readily separated from forms of purulent ophthalmia, are prevalent.

Treatment.—This consists first in search for the cause and the alleviation of associated conditions. The patient must be removed from the influence of dust, cold winds, tobacco smoke,

and the like; the under surfaces of the lids should be examined for foreign bodies, and their borders for misplaced cilia. In the earlier stages cold compresses are agreeable and suitable, but later, frequent bathings with hot water are more acceptable. At first a collyrium of boracic acid (gr. x–f℥j) is useful. The eye should be frequently washed with water and Castile soap.

As soon as the discharge becomes mucous or muco-purulent, and the velvety opacity of the conjunctiva forms, a stronger solution of boracic acid, to which a few grains of common salt may be added, is advisable; and the everted lids should be painted with a weak solution of nitrate of silver (gr. ii–v–f℥j). In severe types, with a considerable discharge, bichloride of mercury (gr. $\frac{3}{4}$–Oj) is a good collyrium.

Other topical medications which have found favor are alum (gr. iv–viii–f℥j), sulphate of zinc (gr. ii–f℥j), which may be suitably combined with boric acid, creolin (1 per cent. solution), and pyoktanin (1–1000), the last, in the experience of the author, having proven very unsatisfactory. Should the thickening of the retrotarsal folds prove stubborn, these may be touched with the alum crystal, or a solution of tannin and glycerin. Atropine is not usually necessary, unless a corneal ulcer complicates the affection.

The eyes may be protected with smoked glasses, but under no circumstances should they be bandaged or be covered with poultices of tea-leaves (which of themselves may produce conjunctivitis—"tea-leaf conjunctivitis"), bread and milk, scraped potatoes, and the like. It should be remembered that meddlesome domestic medication of this sort may change a simple ophthalmia into a serious and purulent inflammation.

At the outset a laxative, followed by full doses of quinine, is indicated; any associated disease, of which the ophthalmia may be a symptom, requires the usual treatment. Proper hygiene, fresh air, strict cleanliness, and protection from contaminated towels, etc., are evident indications.

Purulent Ophthalmia (*Acute Blennorrhœa of the Conjunctiva*) is described under two forms, according as it occurs in the newborn (*ophthalmia neonatorum*), and in adults (*gonorrhœal ophthalmia*).

Ophthalmia Neonatorum.—This is an inflammation of the conjunctiva, characterized in its usual form by great swelling of the lids, serous infiltration of the bulbar conjunctiva, and the free secretion of contagious pus.

Causes.—The affection is caused by the introduction into the eye of the infecting material, from some portion of the genito-urinary tract of the mother, at the time of or shortly after birth. The majority of cases, and all severe forms, are associated with a special micro-organism—the gonococcus of Neisser. Exceptionally, inoculation appears to occur *in utero*, owing, perhaps, to the high degree of penetrating power which has been ascribed to the gonococcus.

Inasmuch as this micro-organism is not invariably present, two forms of the disease have been distinguished—a severe type, supplied with the micro-organism, with a tendency to increase in severity and invade the cornea; and a milder type, non-specific, with a tendency to recover. Hence a virulent vaginal discharge is not necessary to produce this condition, except in intense degree, and it probably may arise from the contamination of any muco-purulent discharge during birth. Careless bathing of the child after birth, and the use of soiled towels and sponges, are fruitful sources of infection. It is possible that later contact with the lochial discharge may originate the disorder, although in the hands of several observers inoculation with healthy lochia has failed to produce the disease.

The exact time of inoculation has not been determined. Infection is more likely to occur in face presentations and during retarded labors. Boys are attacked more frequently than girls. The disease is said to be more common during summer months in cold climates; in hot countries, during the spring and autumn.

Symptoms.—Ophthalmia neonatorum usually begins on the third day after birth, but may set in as early as from twelve to forty-eight hours after inoculation, or, when it is the result of a secondary infection from soiled fingers, sponges or clothes, be delayed to a much later date. Almost always both eyes suffer, the one being earlier, and frequently more decidedly affected than its fellow.

Four stages of the disease are common, but, as these vary in

different cases, and more or less rapidly shade one into the other, no very sharp lines need be drawn.

A slight redness of the conjunctiva, with a trifling discharge in the corner of the eye, is rapidly succeeded by great, cushion-like swelling of the lids, with intense chemosis and congestion of the conjunctiva, accompanied by severe pain and discharge. The surface of the swollen lid is hot, dusky red, and tense; the upper lid overhangs the lower, and at first can only with difficulty be everted. The discharge, which in the beginning is slightly turbid, soon changes to a yellow or greenish yellow pus, and is secreted in great quantities.

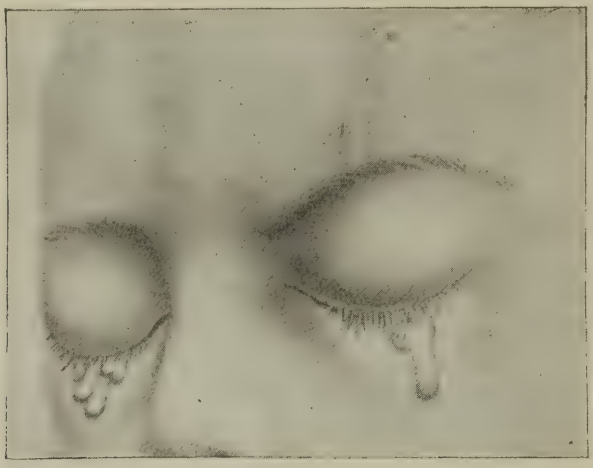
If the lids are everted during the first day or two of the disease, the conjunctiva will be found to be swollen, red, and velvety, and that upon the eyeball intensely injected; upon the surface easily-detached flakes of lymph are found; later, the conjunctiva becomes rough and of a dark-red color, spots of ecchymosis appear, or it is succulent and bleeds easily. Marked chemosis and infiltration of the ocular conjunctiva succeed, forming a hard rim; at the bottom of the crater-like pit thus produced, the cornea may be seen. The thick, cream-like discharge increases, and either flows out from beneath the overhanging upper lid on to the cheek, or is packed up in the conjunctival cul-de-sac. (Fig. 81.)

The lids now may lose much of their tense character, and can be more easily everted; the conjunctiva is puckered into folds and papilla-like elevations, and the discharge contains an admixture of blood and serum. Gradually the disease declines, and in from six to eight weeks the discharge ceases. The relaxed palpebral conjunctiva is thick and granular, looking like the granulation-tissue which surrounds wounds. The ocular conjunctiva is also thickened, and positive cicatricial changes may remain.

The chief risk is destruction of the vitality of the cornea, the danger of which is materially increased if this membrane becomes lustreless, dull, and hazy within the first day or two of the disease. Frequently small, oval ulcers form near the limbus, either transparent or surrounded by an area of cloudy infiltration, which rapidly increase in size; or larger areas of ulceration develop in a more central situation. In many mild cases the cornea escapes without harm. The changes which take place

in the cornea are due in part to strangulation of its nutrient vessels by the swollen tissue, but largely to direct infection by the discharge.

Fig. 81.



Ophthalmia neonatorum. From a patient in the Philadelphia Hospital.

After the formation of a corneal ulcer, either its healing and regeneration of the corneal tissue takes place, or else perforation occurs.

The result of perforation will depend upon the amount and character of the destruction of the corneal tissue. When the ulcer is central and perforates, the aqueous humor escapes, the lens is pressed forward against the posterior surface of the cornea, and the opening becomes closed with lymph. This renders the re-collection of the aqueous possible, and, when it occurs, the lens returns to its proper position, carrying with it upon the anterior capsule a little mass of lymph. Thus the formation of a *pyramidal cataract* results. (See page 395.)

Perforation of an ulcer peripherally situated, especially below, is followed by adhesion of the iris to the opening. The aqueous escapes, and, as the iris and the lens fall forward, the former becomes entangled in the perforation, and is fixed by inflammatory exudation. The adhesion is either on the posterior surface, or in

the cicatrix, and the resulting dense white scar receives the name, *adherent leucoma.*

If the region of the scar is bulged forward because it is unable to resist the intraocular tension, *anterior staphyloma* results. Extensive sloughing of the corneal tissue, with total prolapse of the iris, matting together of the parts by exudation, and protrusion of the cicatrix, constitute a *total anterior staphyloma.*

Finally, perforation may be followed by inflammatory involvement of the ciliary body and choroid, and the rapid destruction of the eye through *panophthalmitis,* or a slower shrinking of the tissues, with *atrophy* of the *bulb.* Dense opacity occasionally appears in the cornea during convalescence, and may go on to ulceration, or clear up perfectly. It may arise with great suddenness, and, when it occurs in the lower half of the cornea, a deep indentation, owing to the pressure of the margin of the lid, is likely to occur.

The appearance of the conjunctiva differs materially in different cases. Its surface may be covered over, not merely with easily-detached flakes of lymph, but with a gray, false membrane. More rarely, a deep infiltration develops, like that seen in diphtheritic conjunctivitis.

Restlessness, fever, and other constitutional disturbances are sometimes present, and synovitis of the knee and wrists may arise, of the same character as similar complications occurring in adults during gonorrhœa.

Ophthalmia neonatorum does not always follow this course, because the term is made to include affections of the conjunctiva in the newborn, other than the types just described—mild catarrhal ophthalmias, hyperæmias, and that variety which, according to Noyes, presents the character of a granular, rather than of a purulent conjunctivitis, and which may continue for weeks without danger of corneal complication.

Some hyperæmia of the conjunctiva, with a little yellowish discharge in the corners of the eye, and slight swelling of the lower lid, is common in babies for a few days after birth, and may be attributed either to uncleanliness, or to change of temperature.

Diagnosis.—The onset and character of the disease, its symptoms and course, render a mistake in regard to its nature practically impossible. Close attention should be given to what at first appears to be a trivial inflammation in the eyes of a newborn child, because a virulent and destructive inflammation may follow with great rapidity.

Prognosis.—This is always grave, the gravity increasing in direct proportion to the violence of the inflammation and the condition of the cornea. The attendants of newborn children should be impressed with the necessity of seeking capable medical advice at the very moment of the appearance of any conjunctival trouble. If, as only too frequently is the case, treatment has been neglected until extensive sloughing of the cornea has occurred, no form of medication can do more than relieve the violence of the inflammation, which, when it subsides, leaves the child with sight hopelessly marred, perhaps destroyed.

Prophylaxis.—The present high standard of scientific midwifery includes such cautious vaginal antisepsis during labor, that the risk of contamination is distinctly less than in former times, but still some preventive method should be employed.

Credé's plan, commonly adopted, yields excellent results. This consists in dropping into the conjunctival sac one or two drops of a two per cent. solution of nitrate of silver, the lids having previously been wiped dry. Other materials recommended for the same purpose are aqua chlorini (Schmidt-Rimpler), and bichloride of mercury. The hands of the mother, nurse, and child should be searched for sources of infection, and, in addition to the usual antiseptic precautions during labor, if gonorrhœa is known to exist in the mother, the child should be removed from the immediate surroundings of the lying-in woman.

Treatment.—If the type is mild, the applications described under simple ophthalmia are indicated; if severe, three conditions demand attention: The inflammatory swelling of the lids, the state of the conjunctiva, and the corneal complications.

(1) During the earlier stages, when the lids are tense and the secretion lacking in its later creamy character, in addition to absolute cleanliness, local application of cold is the most useful agent. This should be applied in the following manner: Upon a

block of ice, square compresses of patent lint are laid, which, in turn, are placed upon the swollen lids and as frequently changed as may be needful to keep up a uniform cold impression. This is far preferable to the use of small bladders containing crushed ice; indeed, the use of ice for infants is not advisable. The length of time occupied with these cold applications must vary according to the severity of the case. Sometimes they may be used almost continuously, and sometimes frequently for periods of half an hour at a time.

On the other hand, hot fomentations are occasionally better than cold, especially when corneal complications exist, or the surface of the conjunctiva is covered with a gray film. These are applied with squares of antiseptic gauze wrung out in carbolized water of a temperature of 120° F., and frequently changed.

(2.) Constant removal of the discharge must be practised.

The lids are to be gently separated, the tenacious secretion wiped away with bits of moistened lint or absorbent cotton, and the conjunctival sac freely irrigated with an antiseptic fluid. For this purpose a saturated solution of boracic acid (which is feebly antiseptic, but very cleansing and slightly astringent), or one of corrosive sublimate, a grain to a pint (it is stated that a solution of one to ten thousand will retard the vitality of the coccus), may be employed.[1] Special and ingenious forms of lid irrigators have been devised. The cleansing process must be repeated at least every hour, day and night, and, if necessary, much more frequently.

The remedies mentioned on page 219 have found favor with some surgeons. In addition to these may be mentioned carbolic acid (one-half to five per cent.), nitrate of silver (one to two per cent.), alcohol and bichloride of mercury solutions, iodoform ointment (four per cent.), and aqua chlorini. Peroxide of hydrogen acts efficiently in cleansing away the purulent secretion. The frequent insertion of vaseline beneath the lids is highly commended.

[1] It is doubtful if bichloride of mercury acts as a potent germicide in these cases, as it is probable that bacteria, in the presence of albumin, have the power to convert it into calomel. Very strong solutions should not be used, because these may injure the corneal epithelium and increase the liability to ulceration.

(3.) The local application of nitrate of silver to the conjunctiva must not be made in the earlier stages before free discharge is established, nor in those cases, no matter what the stage, when the lids are tense and board-like, and the surface of the conjunctiva covered with a gray film, or a false membrane.

When the secretion is free and creamy, when the lids are relaxed, when the conjunctiva is dark-red and puckered into papilla-like excrescences, the time for its application has come. Once a day the palpebral conjunctiva and retrotarsal folds should be brushed over with a solution, ten or twenty grains to the ounce, its surface first having been carefully freed from any adherent discharge, and afterwards all excess of the drug washed away with water. In severe cases the mitigated stick, and even the solid pencil of nitrate of silver may be employed, great care being taken to neutralize the excess with a solution of common salt. All strong applications must be made by the surgeon himself. Ulceration of the cornea does not alter the treatment described, except that pressure upon the globe while manipulating the eye is to be avoided. So long as the discharge is abundant the use of the caustic is indicated.[1]

At the first appearance of corneal haze, a four-grain solution of atropine is to be dropped into the eye two or three times daily. If, however, a marginal ulcer forms, and danger of perforation is imminent, or even if this has occurred, good results are obtained with eserine. The use of eserine requires considerable care, lest any co-existing hyperæmia of the iris be aggravated by the drug, and iritis ensue. For this reason many surgeons prefer not to employ it, although its great efficacy in preventing sloughing of the cornea cannot be denied.

Persistent swelling of the conjunctiva is sometimes treated by scarification. Division of the outer commissure to relieve pressure, leeching, and, indeed, any form of treatment followed by decided loss of blood, are hardly suited to young infants, although they may be indicated in adults.

If one eye alone is affected, suitable protection for the sound

[1] Nitrate of silver combines the properties of an astringent, superficial caustic, and germicide.

eye should be provided. This may be accomplished by antiseptic bandaging of the uninflamed organ (Buller's shield is difficult of application in infants). The daily use in the unaffected eye of a drop of a two per cent. solution of lunar caustic has been suggested.

Reduction of the inflammation with cold applications, for which, under the conditions named, hot affusions are substituted; absolute cleanliness; frequent irrigation with antiseptic and slightly astringent solutions; and at the proper stage nitrate of silver, will meet with the best results.

The attendants must be impressed with the fact that upon their faithful carrying out of directions and upon their unremitting care much, if not all, of the hope of bringing the case to a successful termination depends. The attendants must further be impressed with the contagious nature of the pus; all bits of rag and pledgets of lint used in the treatment must be destroyed, and after each treatment the hands of those engaged must be thoroughly washed and then disinfected with a solution of bichloride of mercury.

Gonorrhœal Ophthalmia (*Purulent Ophthalmia; Acute Blennorrhœa in Adults*) usually can be traced to its source of contagion from an acute gonorrhœa or a gleet, by contact with soiled fingers or linen, or from an eye similarly affected.

Purulent ophthalmia, not gonorrhœal in origin, may be caused by the secretion of diphtheritic ophthalmia, and occasionally by granular lids. Vaginal leucorrhœa is not uncommon in young girls, and from this they may inoculate their eyes. It is to be remembered that a catarrhal ophthalmia by neglect or injudicious external applications, like poultices, may be aggravated into an inflammation in all particulars resembling gonorrhœal conjunctivitis. A few instances of purulent ophthalmia are on record where the source of contagion could not be found, and hence the origin has seemed to be spontaneous.

The same micro-organism described in connection with ophthalmia neonatorum is active in gonorrhœal ophthalmia, the diplococci being found within the cells; later they penetrate the epithelium and enter the lymph spaces in the subconjunctival tissue.

Symptoms.—The first symptoms appear from twelve to forty-eight hours after inoculation, and resemble those already recited in connection with the same disease occurring in the newly born.

The vitality of the cornea is in constant danger, and complications in this membrane may arise during the height of the attack, or later, and when convalescence apparently is established. These consist either in ulcers, small or large, central or peripheral; in the latter position they often exist as grooved rings or small clean cut lesions without infiltration, hidden by the swelling of the surrounding conjunctiva, and very prone to perforate. A more or less dense opacity may follow ulceration, or arise independently of this condition.

If perforation occurs, all the phenomena described on page 223 will ensue, and even without perforation, iritis, cyclitis, and disease of the deeper structures of the eye may develop and defeat the possibility of obtaining good vision.

Gonorrhœal ophthalmia reaches its climax in about ten days, and then gradually subsides in from one to two months; or it may pass into a chronic type and be one of the forms of *chronic blennorrhœa*, which then consists of a general redness of the palpebral conjunctiva, with hypertrophy of its superficial layers and some thickening of the papillæ.

Treatment.—This includes the same principles and practice described in connection with ophthalmia neonatorum (page 224), but requires certain modifications suggested by the adult age of the majority of the cases.

Depletion.—In the beginning, when the inflammatory action is of high degree, a few leeches may be applied to the temple. If the swelling of the lids is so great that their pressure threatens to destroy the cornea, the outer canthus may be divided (canthotomy). This acts in a twofold manner by relieving pressure and by depleting the engorgement through the loss of blood occasioned by the incision, which should be made with a scalpel cutting the tissues from without, down to the bone, as far as the margin of the orbit, but leaving the conjunctiva uninjured. Repeated incisions of the hard rim of chemotic conjunctiva which surrounds the cornea will also relieve pressure. In desperate cases, some operators (Critchett, Fuchs) have not hesitated

to split the lid vertically and stitch the divided portions to the brow, restoring them by a plastic operation after the disease has subsided.

Application of Cold and Heat.—Cold may be applied with compresses in the manner described, or continuously, with Leiter's tubes. Under the circumstances already mentioned, hot applications should be substituted.

Local Applications.—These include the antiseptic lotions previously given, in addition to which may be mentioned a drug which has found favor with many, viz., permanganate of potassium. A solution (1 : 100) is prepared, from which a sufficient quantity is taken to alter one-half pint of water to a deep wine-color, and the lotion then used in the ordinary manner for cleansing the conjunctival cul-de-sac.

At the proper stage, nitrate of silver is the best remedy. It is rarely necessary to employ it in a strength greater than ten to fifteen grains to the ounce, but when the granulations of the conjunctiva become exuberant, the mitigated or solid stick at times alone will control the process.

Corneal Complications.—On the appearance of any of the types of ulceration, the surgeon must decide between atropine and eserine. No question arises if the iris is inflamed, but in the absence of such complication the action of eserine is most favorable. Perhaps the best results follow the use of eserine during the day (gr. $\frac{1}{6}$–$\frac{1}{2}$–f℥j), two drops every three or four hours, and a few drops of an atropine solution (gr. iv.–f℥j), at night. The following formula from Mittendorf is useful :—

℞ Eserinæ sulph., ... gr. j.
Cocain. muriat., ... gr. v.
Aq. destill., ... f℥j.—M.
S. Two drops as directed.

If an ulcer threatens to perforate, paracentesis (page 587) through its floor will diminish the intraocular pressure, and may prevent or lessen the extent of prolapse of the iris. A substitute for this operation is the use of the actual cautery. If perforation has taken place, excision of the prolapsed iris, sometimes recommended, is not without danger, as this procedure may open a way for the entrance of infecting material to the deeper struc-

tures of the eye. Hence in a small prolapse, peripherally situated, the vigorous application of eserine, or, in one centrally placed, the use of atropine, may secure better results. The final outcome of the case will depend upon the extent of corneal involvement, and the ultimate treatment of the remaining leucoma, staphyloma, or shrunken ball will require, according to circumstances, iridectomy, abscission, evisceration, or enucleation.

General Treatment.—If the subject of gonorrhœal ophthalmia is a vigorous individual, the constitution may be brought under the influence of mercury, preferably by inunctions, in the beginning of the disease when there is high grade inflammatory swelling.

Very often the patients are debilitated, and supporting treatment is indicated, quinine, iron, strychnia, and milk-punch, the last especially if there is a tendency to sloughing of the cornea. Any evidences of poor circulation call for digitalis and nux vomica, and these measures modify favorably the failing nutrition of the cornea. The bowels should be kept soluble with calomel, and saline laxatives in the morning. The pain, which is often severe, may be allayed with morphia or opium; indeed, the latter drug has a good influence on the sloughing process. It is a mistake, in the serious forms of this disease, to depend alone upon local measures.

The treatment of a *chronic blennorrhœa*, the sequel of an acute attack, depends upon the degree of thickening in the mucous membrane, but is usually best managed by careful exposure of the thickened conjunctiva and applications of nitrate of silver, tannin and glycerin, and the occasional use of the alum or sulphate of copper stick. As a collyrium, boric acid or bichloride of mercury may be used, or these substituted with sulphate of zinc or acetate of lead, provided there is no corneal ulceration.

Prophylaxis.—Patients suffering from gonorrhœa should be warned not only of the great danger of infecting their own eyes, but the eyes of those around them. Inasmuch as a very minute quantity of urethral discharge, and even when this is the product of a chronic disease, like gleet, may produce acute blennorrhœa, these precautions become the more necessary.

As usually one eye alone is affected it is a matter of great im-

portance to secure the other eye from contact with the secretions. This may be done by sealing it with an antiseptic bandage, the edges of which are made tight by fastening along them strips of gauze painted with flexible collodion, or by the application of Buller's shield. The latter consists of a watch-glass fitted in a square piece of rubber adhesive plaster, which is carefully applied to the brow, temple, lower margin of the orbit and nose, and secured with additional strips to prevent any discharge from getting under the edges. The watch-glass, being directly in front of the eye, permits its inspection and at the same time allows the patient to see.[1]

Fig. 82.



Application of Buller's Shield. (Berry.)

All the precautions which have been stated in regard to the care of ophthalmia neonatorum apply with equal and even greater force in the present disease. The surgeon in attendance, in a number of instances, has been contaminated while in the act of opening the swollen lids, especially if no cleansing lotion has been applied to the conjunctival cul-de-sac for some time.

[1] Care should be taken to provide a watch-glass of the ordinary form, not one with a concave centre.

There is one form of conjunctivitis, occasionally seen during gonorrhœa, which does not depend upon the introduction into the eye of an infecting material from the urethra, but which occurs in patients, who at the same time have articular affections.

The disease is bilateral, mild in character, and resembles a moderate catarrhal ophthalmia with some swelling of the mucous membrane. Iritis has occasionally followed this inflammation, just as it is seen associated with gonorrhœal rheumatism.[1]

The treatment of this affection calls for the same remedies useful in ordinary conjunctivitis.

Croupous Ophthalmia.—This is an inflammation of the conjunctiva characterized by a soft, usually painless swelling of the lids, a membranous exudation upon the conjunctiva, and a scanty sero-purulent discharge.

Causes.—The affection in its pure form is rare. It is never found among the new-born, and rarely among grown-up people, the majority of cases occurring between the first half year of life and the fourth year.

The contagiousness of the disease has not been established; no definite cause is known, although some relation exists between this disorder, scrofula, eczema, and the definite age of childhood just mentioned. Patients affected may at the same time be suffering from a croupous inflammation of the respiratory tract.

Symptoms.—These begin with an acute ophthalmia, succeeded by swelling of the lids, which remains soft and pliant and usually not painful to the touch. In a few days there is a deposit of a characteristic false membrane composed of coagulated fibrin, rather translucent and porcelain-like in appearance, beginning upon the retrotarsal folds, coating the inner surfaces of the lids, but not invading the bulbar conjunctiva. It may readily be removed and shows beneath a granular and somewhat bleeding surface. It is quickly reproduced. The cornea, except in severe cases, escapes.

[1] Some surgeons apply the name "*gonorrhœal ophthalmia*" to this affection, and reserve the term "*gonorrhœal conjunctivitis*" for the disease which is caused by a specific urethral discharge.

Healing takes place in from ten to thirty days except in those instances when the membrane is formed again and again, and the course of the disease may continue for months.

Diagnosis.—The disease may be confounded with ophthalmia neonatorum and diphtheritic ophthalmia. From the former it is distinguished by the absence of profuse purulent discharge and the age of the patient; from the latter, by the soft swelling of the lids and the superficial character of the membrane.

Treatment.—Uninterrupted application of ice compresses, frequent removal of the discharge with a solution of chloride of sodium or chlorate of potash, and later the cautious use of nitrate of silver. (Knapp.) Other applications recommended are dilute lead-water, chalk-water, iodoform and quinine.

Diphtheritic Ophthalmia.—This is characterized by a board-like, very painful swelling of the lids, a scanty sero-purulent or sanious discharge, and exudation within the layers of the conjunctiva which leads to the death of the invaded tissue, and tends, by spreading to the ocular conjunctiva, and by pressure, to destroy the nutrition of the cornea.

Causes.—The disease, which is contagious, may originate from a similar case, or arise in the course of a purulent conjunctivitis. It has occurred, though rarely, with ophthalmia neonatorum. At times it appears in connection with eczema of the face and borders of the lid, and is an occasional accompaniment of some acute illness, like scarlet fever or measles, when the diphtheritic type of the inflammation becomes engrafted upon the conjunctiva. The disease has been seen during epidemics of diphtheria, and may be part of a process which passes from the nose to the conjunctiva, or may be due to direct inoculation with the diphtheritic poison.

It is commonest between the ages of two and eight and is rare in young infants. In certain localities in the south of France and the north of Germany the disease is common; it is comparatively rare in America and England.

Symptoms.—The patches appear in a *discrete* or *confluent* form; the lids are swollen with a characteristic, painful, board-like hardness. The false membrane is of a dull, grayish appearance, and is torn off with difficulty. If the process is deep, the

subjacent structure is pale, infiltrated, and when cut into may be anæmic and lardaceous. If the diphtheritic inflammation has been engrafted upon a case of purulent conjunctivitis, the abundant secretion ceases, or becomes irritating and sanious.

Sloughing of the cornea is almost inevitable in severe cases, coming on with such rapidity that destruction of this membrane may take place in twenty-four hours; and even in mild cases ulcers may be expected.

Restlessness, fever, alimentary derangements and nervous phenomena are usual constitutional disturbances.

This disorder is distinguished from the previous disease by the characteristic board-like infiltration of the lids, and has nothing in common with the flakes of false membrane sometimes seen in purulent ophthalmia, from which it is further separated by the character of the discharge.

Treatment.—During the earlier stages, cold compresses applied in the manner already described are recommended, but as corneal involvement is almost inevitable, hot affusions are more suitable. The eyes should be frequently cleansed with boric acid or bichloride of mercury, and atropine drops instilled which, if the ulceration of the cornea is peripheral, may be replaced with eserine. Scarification of the thickened conjunctiva and rubbing the infiltrated areas with a salve of yellow oxide of mercury have been advised. Besides the collyria mentioned, solutions of salicylic acid in glycerin, and carbolic acid have found favor. The French physicians advise lemon juice and citric acid ointment. Solutions of quinine were highly recommended by Tweedy.

Internally, the most useful remedies are quinine, iron, and mercury; the first in suppositories, and the last either as calomel or as the bichloride, of which $\frac{1}{60}$ to $\frac{1}{40}$ of a grain may be given hourly to a child from three to six years of age.

If one eye alone is affected, the sound eye should be guarded by a bandage, or by Buller's shield. Isolation of the case is necessary, especially if it is in the neighborhood of children who suffer from facial eczema or any form of catarrhal ophthalmia.

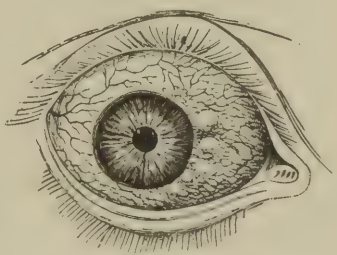
Many writers consider diphtheritic and croupous ophthalmia as subdivisions or different grades of a single disease, known as *plastic* or *membranous ophthalmia.*

Phlyctenular Ophthalmia (*Phlyctenular Conjunctivitis, Scrofulous Ophthalmia, Eczema of the Conjunctiva*).—This is a form of inflammation of the conjunctiva, characterized by the appearance of one or more grayish elevations, situated chiefly upon its bulbar portion in the immediate vicinity of the cornea.

Causes.—The disease is believed to be of constitutional origin, and its subjects are often strumous and badly-nourished children. Errors of diet, over-indulgence in unwholesome foods, and the use of tea and coffee act as predisposing causes. It follows in the wake of the exanthemata, especially measles. Micro-organisms have been described, but inoculations with them were negative.

Symptoms.—The disease occurs in a single and multiple form; the pimples or phlyctenulæ lie near the corneal margin or directly upon it, and are usually from 1 to 3 mm. in diameter.

Fig. 83.



Phlyctenular ophthalmia. (Dalrymple.)

If the elevations are large, yellow, and contain purulent material, the disease has been called *pustular ophthalmia*.

Under any circumstances it is accompanied by pain, dread of light, injected bloodvessels, and increased lachrymation. The conjunctiva may be transparent, or the disorder associated with a muco-purulent ophthalmia. After the exanthemata, this association is common.

In the multiple form, numerous minute phlyctenulæ may be scattered over the entire conjunctiva, and are accompanied by decided general red injection, irritation, and photophobia. The disorder subsides in from ten days to two weeks.

Treatment.—Locally, mild antiseptic collyria, especially a lotion of boric acid, are applicable. Much irritation calls for the use of atropine drops and the *occasional* instillation of cocaine to relieve the photophobia. The eyes may be protected by colored glasses.

After the acute symptoms have subsided, the best results are obtained with the yellow oxide of mercury (gr. 1 to the ʒj), or

calomel, provided the patient is not taking iodide of potash, or, indeed, any form of iodine.

Most important is attention to the condition of the alimentary canal. An excellent regulation treatment is a mild course of mercurial laxatives. Simple nourishing diet, good air, exercise, and internally quinine, iron, arsenic, and in cold weather cod-liver oil, complete the therapeutic measures.

Phlyctenular ophthalmia is so closely allied to phlyctenular keratitis that the separation of the two affections is purely artificial, and this account is a preface to the description of the more exact disposition and relations of the phlyctenulæ, which appears on page 259.

Spring Ophthalmia (*Fruehjahr's Catarrh* (Saemisch), *Phlyctæna Pallida* (Hirschberg)).—This is a form of conjunctival disease, usually seen in children, and is characterized by photophobia, stinging pain, considerable mucous secretion, the formation of flat granulations in the conjunctiva, and a hypertrophy of this tissue surrounding the limbus of the cornea.

Causes.—Definite information in regard to the cause of this peculiar disease does not exist. The characteristic behavior of the disorder has been stated to be its return in the early spring and its subsidence in the fall and winter, although cases are seen in other months of the year, and, moreover, spring and summer exacerbations of ordinary phlyctenular conjunctivitis are marked features.

It is most frequent between the ages of five and fourteen, but occasionally occurs in advanced adult life. It may accompany the disease known as hay fever. Some writers decline to consider vernal conjunctivitis a distinct disease, but look upon it as a hypertrophic form of chronic conjunctivitis.

Symptoms.—The affection begins like an ordinary conjunctivitis and is always bilateral. There are photophobia, more or less mucous secretion, circumscribed peri-corneal injection, and the formation in this region of small, gray, semi-transparent nodules, which swell up and overlap the edge of the cornea.

Three varieties of the disease are described, the *limbus*, *palpebral*, and *mixed* forms. The conjunctiva of the bulb is injected, that of the lids is slightly thickened, of a dull pale color, as if

brushed over with a thin layer of milk (Horner). In severe cases, the tarsal conjunctiva is covered with flattened granulations, containing deep furrows between them. In the colored race, there is a brownish pigmentation of the scleral base of the hypertrophied masses (Burnett).

The disease is to be distinguished from trachoma, by the flattened appearance of the granulations, and the absence of infiltration and pannus.

The *prognosis* of the disorder is not unfavorable, except in so far as relapses are concerned, which make its course a long one, often lasting from eight to ten years. Slight opacity of the cornea may result.

Treatment.—During the height of the attack, the eyes may be protected with dark glasses; weak astringent and antiseptic lotions are applicable. Calomel, yellow oxide of mercury, iodoform ointment, boroglyceride, and strong solutions of bichloride of mercury have been recommended.

The exceedingly troublesome nature of this affection and its constant tendency to recur, have led some surgeons to use the actual cautery to destroy the flattened granulations and hypertrophied masses at the limbus of the cornea. Incision of the superficial vessels which run from the outer and inner commissure and empty into the swelling at the limbus, has been performed, and electrolysis has been employed.

Follicular Ophthalmia (*Follicular Conjunctivitis, Conjunctivitis follicularis simplex, Trachoma folliculare*).—This affection is characterized by the presence of small, pinkish prominences in the conjunctiva, for the most part in the retrotarsal folds, and usually arranged in parallel rows.

Causes.—The disease arises under the influence of bad hygienic surroundings, especially in pauper schools (where it may appear as an aggravated epidemic), but it is frequently seen in mild form, especially among children during their school years.

Much difference of opinion exists as to whether follicular conjunctivitis should be placed in a separate category from granular ophthalmia, or whether it should be regarded as an early stage of the latter disease. Although transitional forms apparently exist, the evidence, clinically at least, warrants the belief that

many forms of this affection are very distinct from granular lids. Bacteriologically, the two disorders are believed to be identical.

Symptoms.—The children—for it mostly occurs in children and young people—complain of slight dread of light and inability to continue at close work, and inspection reveals numerous round elevations in the conjunctiva, chiefly along the fornix, which are tumefied lymphatic follicles. These may not be evident at first, if there is associated with the disorder a catarrhal condition of the conjunctiva. The color of the follicles varies from nearly white to a decided pink. After their disappearance the conjunctiva regains its natural state.

The disorder is to be distinguished from granular lids, by observing that the small bodies are neither so large as true granulations, nor so highly colored as hypertrophied papillæ; that the mucous membrane is not affected more deeply than the lymphatic follicles; and that cicatricial changes are not present.

The *prognosis* is good in so far as the fate of the mucous membrane is concerned, but the disorder is troublesome and will often last for months, and under imperfect hygienic surroundings and in crowded asylums, may prove a stubborn endemic.

Treatment.—Locally, boric acid, either alone or made up with a few minims of alcohol to one ounce of water, weak bichloride solutions, and occasional application of iodoform or aristol, or subnitrate of bismuth and calomel, equal parts, are the best medicinal measures. A salve of one-half grain of sulphate of copper to the drachm of vaseline has been highly extolled.

Refractive error, if it exists, should be corrected with appropriate glasses, because ametropia aggravates the disorder. In stubborn cases, especially in asylums, excision of the affected areas and crushing the swollen follicles have been recommended.

Granular Ophthalmia (*Granular conjunctivitis, Trachoma, Egyptian ophthalmia, Military ophthalmia*).—This is an inflammation of the conjunctiva in which the membrane loses its smooth surface, owing to the formation of rounded granulations, which, after absorption, leave cicatricial changes. It may be studied under two forms—*acute granulations* and *chronic granulations.*

Causes.—*Acute granulations* may arise primarily under the influence of bad hygienic surroundings and develop in institutions where the inmates are crowded together. The disease is propagated by the secretion of one eye coming in contact with another, and perhaps through the atmosphere, and is more likely to attack subjects whose nutrition has been enfeebled by scrofulosis and tuberculosis, but it is not caused by these dyscrasias.

Acute granulations, in the true sense of the term, is not a common disease in this region, and must not be confounded with the violent exacerbations to which the chronic forms of the malady are liable.

Chronic granulations may result from the imperfect disappearance of the acute granulations, but much more frequently appear as a primary disorder, and when no such ancestry can be traced.

Certain individuals are predisposed to the development of chronic granular ophthalmia, and although its subjects are often pale and anæmic, because they live in badly ventilated homes, there is no proven constitutional disorder which causes the disease, as it may attack those who are in perfect health. This predisposition is not confined to individuals, but includes races, the Jews, the Irish, and the inhabitants of the East, as well as the Indians in our country, being especially liable to the affection, while the negroes are almost exempt. These facts have led a few observers to believe that there must exist in the form of a dyscrasia a predisposition to this disease (Burnett).

The geographical distribution of trachoma has attracted much attention, and it has been found that the dwellers in certain regions of the earth, where the climate is damp, are readily affected, while an altitude of 1000 feet confers comparative immunity from the disease, and facilitates its cure.[1]

At the present time, a large amount of evidence based upon bacteriological research has accumulated, indicating the dependence of granular lids upon the presence of a special form of micro-organism. The trachoma-coccus, if it exists, has not been definitely found out, and the various observers are not in accord as to its identity; indeed, some of them deny the possibility of

[1] According to Burnett, trachoma has been seen at an altitude of 4700 feet, particularly among Indians.

this mode of origin. The contagious nature of the affection is undoubted, being less marked in the earlier stages of the eruption of the granulations, but rising in proportion to the degree of softening of the affected tissue, and corresponding amounts of discharge. It is usually taught that the secretion from a case of granular lids will produce not only a purulent ophthalmia, but a disease like the one from which it came, and, in this sense, is specific.

Nature of the Granulations.—The pathognomonic appearance and essential element of the disease trachoma are the "granulations,"[1] but the life history and pathological histology of these bodies, and the identity or non-identity of follicular ophthalmia and granular lids have not been entirely settled.

Two views have been held—the one that they are new growths of special pathological character; the other that they are derived from the natural lymphatic follicles, and some authors declare that these follicles, and their changes, originate all the anatomical and clinical qualities of trachoma.

The weight of evidence, however, points to the presence of two forms of disease—follicular conjunctivitis, characterized by tumefied lymphatic follicles (p. 237), and trachoma, identified by the development of trachomatous nodules, which should be regarded as new formations.

The following varieties of chronic trachoma have been recognized by systematic writers:—

1. *Papillary trachoma*, in which the trachoma bodies or follicles are sparsely present and hidden from view by hypertrophied conjunctival papillæ. This form is sometimes spoken of as *chronic trachoma.*

2. *Follicular trachoma*, in which the presence of the "follicles" is the chief characteristic. Here the term "granulations" is often made synonymous with "follicles;" this may lead, as has been pointed out, to a confusion of the latter bodies with surface granulations that may form during the course of the disease (Johnson), unless it is understood that the characteristic feature

[1] It should be remembered that the word "granulations" refers to the characteristic feature of trachoma, and not to surface granulations which may form during the course of the disease.

of the disease is meant by the word granulation. Some authors consider follicular ophthalmia (page 237) a variety of this type, but owing to its marked clinical differences it has been considered in this book under a separate caption.

3. *Mixed trachoma*, in which the follicles or bodies lie among hypertrophied and inflamed papillæ, but are not hidden by them. This type is sometimes described as *diffuse trachoma*.

Symptoms (*Acute Granulations*).—The lids are swollen, the conjunctiva reddened, and the papillæ hypertrophied, and between them are found the non-vascular, roundish "granulations." The dread of light is intense, and, on forcible separation of the lids, scalding tears gush out. The bulbar conjunctiva is injected, superficial vascularity of the cornea arises, and ulceration, especially of its margin, may appear.

The patient complains of pain in the eyebrow and temple. At first the discharge is scanty, but later a muco-purulent stage begins, succeeded by purulent discharge.

The process terminates, either favorably, by the absorption of the granulations, or runs into the chronic form.

(*Chronic Granulations*).—These often appear without antecedent inflammation, and so insidiously that their real nature is for a time unknown to the patient. They usually develop first upon the lower lid, in the form of grayish-white, semi-transparent bodies, which vary in size according to their stage of development, and which, from fancied resemblances, have been called "sago-grain," or "vesicular" granulations. They may be disseminated or arranged in parallel rows, and have sometimes been likened to the appearance of frog's spawn. The granulations are for the most part confined to the palpebral conjunctiva, and the upper retrotarsal fold (which is a favorite location) should be well exposed during the examination. Occasionally granulations are found upon the caruncle and semilunar folds.

The mucous membrane is pale or yellowish-red, unevenly rough, and contains the trachoma bodies, or follicles, which have a more or less deep situation and fill up the tissue. If they have not followed an acute process, there are few irritative manifestations and little discharge, perhaps only sufficient to glue together the lids. As time goes on the closely packed masses compress the true con-

junctival tissue and its circulation, and a superficial vascularity of the cornea may appear. This stage may last for months and be subject to numerous variations.

In the next stage vascularity is increased, the follicles grow larger, soften, and their contents are forced out by the pressure of the surrounding infiltrations, forming, in association with the hypertrophied conjunctival papillæ, red protuberances (mixed and papillary granulations). This period is associated with strong irritation and muco-purulent or purulent secretion, photophobia and symptoms of local pain, with fresh development of corneal complications.

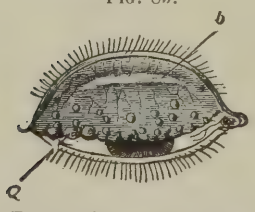
Fig. 84.



Exuberant "granulations." No indications of cicatrization are present. (Jones.)

During the time of fatty degeneration and softening, which by some authorities is deemed a process of ulcerations, fresh follicular (granular) eruptions take place, in turn to go through the same changes which their forerunners have undergone. The mucous membrane now has a flesh-red appearance; it is with difficulty that the "granulations" are distinguished from the papillæ, and indeed they are united with them, forming variously shaped diffuse or isolated protuberances.

Fig. 85.



Typical Granular Lid and beginning Cicatrization. *a*. Granulation. *b*. Cicatrix parallel to lid border. (Nettleship.)

In the final stage cicatrization begins, and gray-white scar lines appear, intersecting the remains of the old "granulations." When these cicatrices lie parallel to the ciliary borders they form on eversion of the lid a typical appearance.[1] (Fig. 85.)

By a gradual process of cicatrization of the old "granulations" and successive new crops, a chronic indu-

[1] It is convenient thus to divide the disease into three stages, as Raehlmann has done, but it is not always possible to separate sharply each stage by symptoms or appearances peculiar to itself.

ration and diffuse scar tissue results. This being firmly attached to the tarsus, which itself has undergone softening through a lymphoid infiltration, contracts, and the deformities of the lid and its border, so common in this disease, result. The fibroid induration of the mucous membrane affects all portions, and there may be almost entire obliteration of the conjunctival sulcus, or the membrane may undergo a species of drying up to which the name *xerosis* has been applied. Individuals with granular lids, in the stage of thickening of the mucous membrane, have an almost characteristic sleepy look, peering uncertainly through narrowed palpebral fissures, caused by the ptosis-like droop of their indurated eyelids.

Sequelæ of Granular Lids.—The most important results of long-standing granular lids are trichiasis, distichiasis, and entropion, conditions already described (page 209), atrophy and shrinking of the conjunctiva from cicatricial changes (page 249), cloudiness and ulceration of the cornea, and *pannus*.

Pannus may be looked upon as a form of *vascular keratitis*, which always begins under the upper lid, but which in severe cases may involve the entire cornea. It depends upon the formation of a superficial bloodvessel tissue, continuous with the vessels of the conjunctiva. It may be composed of only a few vessels, or be thick, fleshy, and bulging in appearance. Unless softening and ulceration occur, which is not infrequently the case, the true corneal tissue is not much affected.

It is usually taught that pannus is mechanical in origin and is caused by the friction of the granulations. According to Raehlmann, however, it should not be considered as a simple traumatic irritation, but as a follicular process, with the formation of lymphoid infiltration, analogous to the same pathological condition in the conjunctiva; in short, pannus is to be regarded as a special implantation of the trachoma process in the layers of the cornea.

Fig. 86.



Formation of vessels in the cornea. Pannus. (Nettleship.)

Extensive and deep ulceration may complicate pannus, which in turn may lead to the development of iritis.

Diagnosis.—This presents no difficulties. Acute granulations must be distinguished from purulent ophthalmia, but the chronic form is made evident by direct inspection of the everted lids, unless the associated swelling of the papillæ is so great as to obscure the "granulations," especially in the forms of papillary trachoma. Hypertrophied conjunctival papillæ, chronic blennorrhœa, or surface granulations must not be mistaken for trachoma. The clinical distinctions existing between trachoma and follicular conjunctivitis have been pointed out.

Prognosis.— Under the best circumstances, granular lids when well established is a tedious disease, and greatly endangers the vision of the patient. Relapses are frequent, and at any time the disorder is likely to assume an intense inflammatory action analogous to acute granulations. Its contagious character renders the affection especially dangerous in schools or any institution where large numbers of inmates are gathered together. The discharge, even when present in slight degree, is readily conveyed from one subject to another by the careless use of towels and common utensils. Great caution is necessary under such circumstances to prevent a disastrous epidemic.

Treatment.—*Acute Granulations.*—These are managed upon the principles which govern the treatment of acute ophthalmia generally, and in the earlier stages, require soothing remedies rather than strong astringents.

Chronic Granulations.—The treatment of chronic granular lids may be divided into three methods: Local application of caustics and astringents, operative procedures, and general medication.

Local applications include the astringent and caustic preparations which are used to cause absorption of the "granulations," but these should not be of such strength that they will produce cicatricial changes more harmful than the original malady. A variety of substances has been employed, and among them four have met with deserved favor—strong solutions of bichloride of mercury; nitrate of silver; sulphate of copper, either in the form of a crystal, or as *lapis divinus;* and boroglyceride.

During the stage of conspicuous lymphoid infiltration and decided follicular ("granular") eruption, without the presence of purulent discharge, bichloride of mercury, 1-300 or 1-500, may be applied to the everted lids, with an absorbent cotton-mop, from once a day to thrice weekly, according to the amount of reaction produced, the conjunctival cul-de-sac being frequently irrigated during the day with a tepid solution of the same drug (1-8000).

In the stage of softening of the granulations and swelling of the conjunctival papillæ, associated with muco-purulent and purulent discharge, nitrate of silver, applied in the same manner and with the same precautions that have been described under Purulent Ophthalmia, is the best remedy.

During the same stage in which strong solutions of bichloride of mercury have been recommended, or, as it seems to the author, more properly at a somewhat later period, when eruption of new granulations is associated with beginning cicatricial metamorphosis of old crops and their surrounding tissue, but when there is no purulent discharge, sulphate of copper crystal is a standard remedy, and is the one usually recommended for routine treatment. The crystal should be smooth and carefully applied to all portions of the affected areas, especially to the retrotarsal folds, and the treatment followed by washing the surface with cold water. It is a painful remedy, and in sensitive patients, there is no objection to cocainizing the eye preparatory to its use.

During the later stages, to hasten absorption of remaining granulations, and, perhaps, to prevent the tendency to xerosis, boroglyceride (30–50 per cent.) is a useful remedy, applied in the usual manner with a mop of cotton. Some surgeons employ this drug in all stages of the disorder.

Among the many remedies which have been tried in this affection, the following may be mentioned: Liquid carbolic acid, liquor potassa, betanaphthol, hydrastin, iodoform or aristol (in powder or salve), an ointment of the yellow oxide of mercury, calomel, and iodide of silver. In mild cases, or after an impression has been made with stronger caustics, a favorite astringent is tannin and glycerine (30-60 grains to the ounce), or the everted lids may be touched with an alum crystal.

During the course of the treatment, the affected areas should be

frequently irrigated with saturated boric acid or weak bichloride of mercury solutions; if much discharge is present, this is imperative. At any time granular lids are liable to take on acute symptoms: increased discharge; exacerbation of pannus, with clouding and ulceration of the cornea; hyperæmia of the iris; and acute pain in the brow and temple. Usually, strong local applications must then be discontinued, and the treatment instituted which is applicable to an acute ophthalmia. Cold compresses, more suitably substituted by hot applications if there is much corneal disease, frequent cleansing with tepid boric acid lotion, leeches to the temple, and atropine to keep the pupil dilated, unless this drug itself should aggravate the granular condition, when it may be replaced by hyoscyamine, are then indicated.

Operative Procedures.—This includes the various methods for removing the granulations by scarification of the conjunctiva; abscission of the granulations; excision of the retrotarsal fold; destroying them, when discrete, by picking them out one by one with a fine needle and emptying their contents, or burning them with a heated wire or galvano-cautery; and squeezing them out between the thumb-nails, or with specially devised forceps, the two most satisfactory instruments for this purpose being the model of Noyes, and the forceps, on the principle of a roller, advocated by Knapp. Exuberant granulations have been scraped away with a small rake or a sharp curette; or removed by rubbing them briskly with a stiff brush, and then applying strong solutions of bichloride of mercury (*"grattage"*).

Great care must be exercised in practising any of these methods, lest the scar resulting from the operation, produce deformities in the lid greater than those likely to be occasioned by the disease; hence if the hot needle or galvano-cautery is used, the isolated trachoma bodies alone must be attacked, and the surrounding conjunctiva carefully excluded. Of the methods just enumerated, squeezing out of the granulations with forceps is the most satisfactory.[1] During its performance, the area of operation should be flooded with tepid bichloride collyrium, and cold compresses afterwards applied to subdue inflammatory reaction.

[1] The squeezing operation is more suited to the follicular forms of trachoma than to the other varieties.

Finally mention may be made of the method by electrolysis recently advocated by Mr. George Lindsay Johnson.

Treatment of Pannus.—If this is limited in degree, it requires no special treatment as it will disappear with the absorption of the granulations. But if it is extensive, and especially if associated with ulceration, special treatment should be directed towards its cure. This includes the local remedies which are appropriate for a vascular keratitis, viz., an antiseptic lotion, and atropine, or eserine. The former should be used if any tendency to iritis exists, and if it does not aggravate the granular condition; the latter, when ulcers are present. It is suitably enforced by the use of atropine at night.

Inveterate pannus without ulceration of the cornea, may be treated by the production of a violent conjunctivitis, characterized by the formation of a somewhat clinging false membrane, with a 3 per cent. infusion of jequirity painted upon the everted lids. This method was introduced by De Wecker to substitute the old-fashioned inoculation of the conjunctiva with blennorrhœic pus. It is safe only in stubborn cases with much impaired vision. It has also been advised to apply the same drug in fine powder, a little at a time, exactly upon the portion of the granulations to be absorbed.

The operation of *peritomy*, which consists of an excision of a ring of conjunctival tissue surrounding the cornea, has been much practised for the relief of severe pannus. Another method is to scrape away the opaque and vascular areas in the cornea with a small knife (Gruening). If the palpebral fissure becomes contracted by cicatricial changes, or if during inflammatory periods in trachoma, the lids dangerously compress the cornea, the operation of *canthoplasty* affords relief.

General Medication.—It is a mistake to depend solely upon local measures for the relief of granular ophthalmia, for although the disease has no proven constitutional origin, its subjects give frequent evidence of malnutrition, and are sometimes affected with the scrofulous or tuberculous dyscrasia. Hence, in addition to every advantage that fresh air—if possible, at a high elevation—good food, and pleasant hygienic surroundings can give them, iron, cod-liver oil, hypophosphite

of lime, arsenic, and, in short, a general tonic regimen should be exhibited. Suitable attention to the alimentary tract is important.

Chronic Ophthalmia (*Chronic conjunctivitis*), the result of an acute blennorrhœa, has been referred to on page 228.

As an independent disorder, and assuming more the type of a hyperæmia, it is a common disease in elderly people. There are hyperæmia, thickening of the papillary layer of the tarsal conjunctiva, swelling of the caruncle, soreness of the edges of the lids, especially at the outer canthus, and slight muco-purulent discharge.

Treatment.—Cleanliness, with antiseptic lotions, the application of "lapis divinus," the alum crystal, or glycerole of tannin (gr. x–f℥j), are useful local measures. The puncta lachrymalia should be examined, and if they are closed they should be dilated and the lachrymal passages irrigated with an Anel syringe. Refractive error, which may keep up congestion, requires correction.

Egyptian and **Military Ophthalmia** are terms which have at different times been loosely used to describe all forms of conjunctival inflammations, occurring in crowded barracks and similar institutions, which assumed an epidemic tendency, pursued a more or less chronic course, and hence included varieties of acute and chronic blennorrhœa and muco-purulent ophthalmia, in addition to those cases which possessed as a fundamental diagnostic symptom, "granulations" of the conjunctiva, and which eventuated in the formation of cicatrices.

Lachrymal Ophthalmia is really a form of chronic conjunctivitis depending upon obstruction of the lachrymal passages, and the frequently associated blepharitis. The eyelids are inflamed upon their borders, the cilia gathered in little tufts by the formation of small pustules at their bases, the conjunctiva is injected and tear-soaked, and there is a somewhat gummy discharge.

The *treatment* requires that the lachrymal passages shall be rendered patulous, in addition to the ordinary remedies suitable for chronic ophthalmia and ulcerated blepharitis.

Lithiasis Conjunctivæ is a troublesome condition caused by a calcareous degeneration of the secretion at the mouths of the

Meibomian ducts. It is more commonly seen in elderly people than in young subjects, especially in such as are rheumatic. On everting the lids, numerous small, yellowish-white concretions will be seen, distinctly gritty to the touch. These act like so many foreign bodies, and produce considerable irritation and pain.

Each concretion should be removed with a fine needle, the conjunctiva having first been rendered insensitive with cocaine.

Toxic Ophthalmia is a name suited to those forms of conjunctival inflammation caused by exposure to the influence of certain chemicals, or by the prolonged use of the mydriatics (notably atropine) and myotics.

Atropine Conjunctivitis occurs at all ages, but is commonest in old people. Sometimes it will appear after only a few drops of the solution have been used, but usually not until the drug has been employed for a long time. Attempts have been made to explain it by assuming impurities in the drug, the existence of free acid, a septic origin owing to the presence of a fungoid growth, and idiosyncrasy. In a number of instances arthritic history has been obtained (Collins). The disease usually appears in the form of follicular granulations, sometimes associated with much swelling of the lids, and an eczematous condition of the surrounding tissue.

Eserine, hyoscyamine, duboisine, and homatropine less commonly cause this affection, and the same disorder has been reported as the result of the prolonged use of cocaine.

Conjunctivitis is known to occur among those who work in aniline dyes, and also as the result of chrysophanic acid, when this has been used as an ointment in chronic skin affections.

The *treatment* in general demands the removal of the cause, and in atropine conjunctivitis, applications of tannin and glycerine and of the alum crystal are very useful. In some instances the author has found a 1 per cent. solution of creolin of service. A bland ointment for the irritated cutaneous surface is indicated.

Xerophthalmos (*Atrophy of the Conjunctiva; Xerosis*) is the name employed by systematic writers to describe a dry, lustreless and shrunken appearance of the conjunctiva, and is recognized under two forms—*parenchymatous* and *epithelial*.

The former type results from cicatricial changes which involve

the deep layers of the conjunctiva; the sulcus is obliterated, and the lids, in severe cases, are attached to the eyeball, while the cornea is opaque. The surface of the conjunctiva of the lids is smooth, dry, and almost leathery to the touch. Granular lids, diphtheritic ophthalmia, pemphigus, and essential shrinking of the conjunctiva are the causes of the disorder.

TREATMENT is of no avail, but some comfort may ensue by instilling glycerine and water, or by the local use of an emulsion of cod-liver oil.

In the *epithelial type* the exposed ocular conjunctiva becomes dry and has a lack-lustre appearance; cheesy flakes form, and the membrane is greasy and thrown into folds. This form of xerosis sometimes occurs in epidemics, associated with night-blindness, and is seen among people of poor nutrition—for instance, during prolonged fasts—or among soldiers whose eyes have long been exposed to sunlight. It is also one of the symptoms of kerato-malacia in infants. (See page 279.)

The *treatment* demands a nutritious diet, a soothing collyrium, dark glasses, and removal from the surroundings which have caused the difficulty.

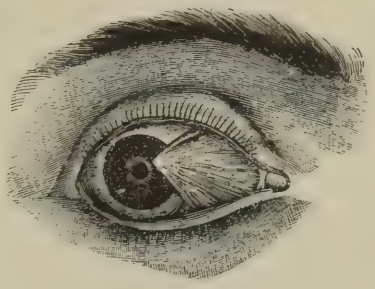
Amyloid Disease of the Conjunctiva is a rare disorder, in which pale, yellowish masses appear chiefly in its palpebral portion. It has been supposed to arise from granular ophthalmia, but, according to Raehlmann, the growths are independent of trachoma.

Extirpation is the proper mode of treatment. Their structure is analogous to lymphoid tumors in which a hyaline degeneration may be found, and which in all probability is an antecedent condition. The diagnosis can be made with certainty only by submitting the tissue to the iodine test.

Pterygium is a peculiar fleshy growth, consisting of hypertrophy of the conjunctiva and subconjunctival tissue. One or both eyes may be affected. Its most usual situation is at the inner side of the eyeball, corresponding to the course of the internal rectus muscle; more rarely it develops at the outer, and very exceptionally at the upper or lower part. When the fan-shaped expansion arises from the semi-lunar fold and caruncle, it converges as it approaches the cornea, the centre of which it rarely passes.

The growth, never of very frequent occurrence, is rare in children. It is most common in warm climates. Individuals whose occupation exposes them to dust, smoke, heat, and slight injuries of the cornea are predisposed to its formation. Ulceration at the margin of the cornea has been regarded as the primary cause of pterygium. One theory explains its origin by assuming an influence exerted by the internal recti during convergence, over the blood supply of the conjunctiva, covering their insertion (Theobald). Special bacteria have been invoked as its etiological factors. Pterygium occasionally results as a sequel of blennorrhœa, during which the thickened conjunctiva has become attached to a corneal ulcer.

Fig. 87.



Pterygium (Meyer).

The *treatment* consists either in excision, transplantation, strangulation by means of ligatures, or evulsion (page 585).

Pinguecula is a small, yellowish elevation situated in the conjunctiva near the margin of the cornea, and usually at the inner side. It has the appearance of fatty tissue, but really is composed of connective tissue and elastic fibres. It causes no inconvenience and rarely grows to a size sufficiently great to be disfiguring.

It may be removed by picking it up with small forceps, excising with scissors, and drawing the lips of the wound together with a fine suture.

Abscess of the Conjunctiva is a rare condition, in which a localized area of suppuration appears in the subconjunctival tissues. It may develop in children of greatly depressed nutrition, and has been the sequel of a wound.

Ecchymosis of the Conjunctiva.—This is an extravasation of blood beneath the conjunctiva scleræ, the meshes of the connective tissue being filled with blood-clot, and occurs as the result of an injury, or from some violent, straining effort, *e. g.*, during a paroxysm of whooping-cough. It may arise without obvious

cause, especially in elderly people, and has been seen in young girls at the time of the menstrual epoch. Its occurrence during severe conjunctival inflammations has been described. Ordinarily, subconjunctival hemorrhage will subside by absorption, and requires no treatment.

Chemosis (*Œdema*) **of the Conjunctiva** occurs when the connective-tissue layer is distended with serum, and is often associated with an inflammatory exudate. It is generally a symptom of some other disease—for example, acute conjunctivitis, choroiditis, iritis, or orbital cellulitis. Severe œdema of the conjunctiva, with swelling and hyperæmia, may appear without any apparent cause, and with marked suddenness. In paralysis of the external straight muscles the overlying conjunctiva is often decidedly œdematous, and may be an early symptom of such an accident. Chemosis of the conjunctiva following the use of iodide of potash has been reported, and it may succeed a general outbreak of urticaria.

Treatment.—The swollen tissues may be incised, and an astringent lotion, like alum, prescribed.

Emphysema of the Conjunctiva consists in a distension of the connective-tissue spaces with air, and occurs under the same circumstances which occasion this accident when it involves the eyelids.

Lymphangiectasis of the Conjunctiva is a development of small blisters in the conjunctiva, filled with semi-transparent fluid, and usually gathered together in masses. These are situated superficially, and readily move with the conjunctiva over the subjacent tissue. An interference with the natural lymph flow and consequent distension of the lymph spaces is the probable explanation of their appearance. The affection is said to be most frequent in children, but may occur at any age. Spontaneous disappearance is the common outcome, but, if need be, the small blisters may be incised.

Syphilis of the Conjunctiva.—Chancres may develop on the upper or lower cul-de-sac, and even upon the ocular conjunctiva, as primary affections, and not only as extensions from the lids. A few instances of soft chancre have been described.

As manifestations of general syphilis, ulcerated papular syphi-

lids and gumma of the conjunctiva have been recorded. Finally, there is a type of ophthalmia called *syphilitic conjunctivitis*, which appears as a stubborn catarrh, or in the form of granulations, similar to trachoma follicles, developed in an anæmic and rather colloid-looking conjunctiva. Its subjects have been cases of pronounced syphilis, and the disease is not amenable to local treatment, but disappears under anti-syphilitic remedies.

Tumors and Cysts of the Conjunctiva.—As congenital forms, translucent cysts, angiomas, lymph-angiomas, dermoid growths (see page 298), and pigment spots have been described. Although the latter may be congenital, it should be remembered that they may also appear after the healing of variolous pustules, when these occur upon the conjunctiva.

The cysts are not common. Sometimes several are seen in the region of the retrotarsal folds as small, oval, perfectly clear bodies causing no irritation, or as spherical growths upon the bulbar conjunctiva.

Among the benign tumors, lipoma, fibroma, osteoma, and papilloma have their habitat upon the conjunctiva. Lipoma is most common in the region between the superior and the external rectus. Papillomas, or polyps, have been confounded with bunches of granulation-tissue arising from wounds, *e. g.*, after strabismus operations. *Cysticerci* have been extracted from the subconjunctival tissue. They are movable under the conjunctiva, have moderately thick and vascular walls, upon which an opaque, white spot is seen, indicating the presence of the receptaculum. This appearance is said to be pathognomonic.

Treatment.—Excision with scissors curved upon the flat, is readily performed in all these instances. The wound may be united with fine sutures. In simple cysts, cutting away the anterior wall is usually sufficient to cause a cure.

The malignant growths include epithelioma and sarcoma.

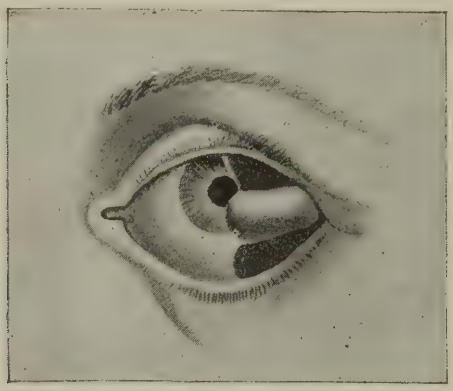
Epithelioma may occur as a primary growth upon the ocular conjunctiva, especially at the limbus corneæ. In the latter situation it appears as a reddish elevation, surrounded by injection. Finally, there are ulceration and implication of the cornea.

The growths are stated to be non-pigmented, but a number of pigmented or melanotic tumors have been removed from this

region, which proved to be of epithelial structure. In a large collection of cases, Noyes has described other tumors found in this situation, not conforming to the type of epithelioma, but included under the general term *carcinoma*.

Sarcoma of the conjunctiva arises at the limbus, in the form of a reddish-white growth, usually overlapping the cornea, but not involving its structure. Both pigmented and unpigmented varieties occur, the former being the more frequent. They may grow rapidly and reach a large size.

Fig. 88.



Sarcoma of the conjunctiva. From a patient in the Philadelphia Hospital.

Removal of these growths by means of knife or scissors is practicable in the early stages, without sacrificing the eyeball. In the later stages, or when the extirpation cannot be made complete, enucleation is necessary.

Lepra.—According to Lopez, the chief alterations in the conjunctiva produced by leprosy are anæsthesia, inflammation, pterygia, and tubercles. The anæsthesia of the cornea probably determines the chronic conjunctivitis which is common. Pterygia are frequently observed, and are caused by the action of external irritants upon the ocular conjunctiva which has become insensitive under the influence of the disease.

It is convenient in this place to refer to the effect of leprosy upon the cornea, in which the lesions are frequent and varied.

The tubercles which form in the conjunctiva are apt to attack the corneo-scleral margin, but may involve the cornea exclusively. A late manifestation of the disease is an inflammation of the cornea known as *leprous keratitis*, which somewhat resembles interstitial keratitis.

Lupus occurs as a primary disease, or extends to the conjunctiva from the surrounding integument. It appears in the form of red, granular patches placed upon an ulcerated base. As the same microbe is the cause of lupus and tuberculosis, any difference existing in the two diseases when occurring in this situation, must rest upon the clinical appearances, the lupus spot showing healing in one direction and active ulceration in another. Those cases in which the disease has spread from the lid to the conjunctiva have especially been classified as lupus.

Tubercle of the Conjunctiva occurs as a *primary* and as a *secondary* affection.

Primary tuberculosis of the conjunctiva is rare, but a certain number of undoubted instances are upon record in which there was an absence of evidence of tuberculosis elsewhere, and in which there was no reappearance of the disease locally, or in distant organs, after its removal.

As a secondary affection it has usually appeared in association with nasal and laryngeal tuberculosis.

The chief *symptoms* are a somewhat resisting thickening of the lids; dark-red swelling of the conjunctiva, especially of the retrotarsal fold, which is beset with grayish-red nodules resembling the follicles in granular ophthalmia; and ulcers with uneven and slightly raised edges, whose floors have a lardaceous appearance, or are covered with grayish nodules, slightly sloughing in their apices. There is considerable discharge, and occasionally swelling of the tear-sac. The pre-auricular and submaxillary lymphatic glands of the same side are enlarged. Pain is not considerable unless the ulceration involves the bulbar conjunctiva and cornea, or extends to the lids.

The disease should be distinguished from trachoma, epithelioma, and syphilitic ulceration.

Diagnosis.—In any suspected case, the real nature of the affection may be decided at once by excising a portion of the

diseased tissue, submitting it to bacteriological examination, and demonstrating the presence of tubercle bacilli.

In trachoma the lymph-glands are not involved, and the follicles in acute cases will yield to treatment with sulphate of copper, while in tuberculosis this is ineffectual (Knapp). In the stages of the follicular formation of this disease, the discovery of the bacilli is the only positive differential diagnostic point.

Epithelioma is excluded by the age of the subjects, tuberculosis almost invariably occurring in young people.

Prognosis.—This depends upon whether the disease is primary or secondary. In order to prevent general infection, it is important to eradicate the local lesion. Sight may be destroyed by involvement of the cornea.

The *treatment* demands destruction of all the diseased tissue. This is best accomplished by removal with a knife, curette, or the galvano-cautery. The subsequent treatment should include the use of a collyrium of bichloride of mercury, and iodoform or aristol powder. Injections with the fluid of Koch have shown their greatest efficacy in local chronic tuberculosis (lupus), and might be tried here, not only as a curative, but also as a diagnostic agent.

Pemphigus of the Conjunctiva is a rare affection, characterized by the formation of bullæ, associated with pain and lachrymation, and, after succeeding attacks, degeneration and cicatrization of the conjunctiva. It is doubtful whether this occurs as an independent disorder; it is usually seen in connection with pemphigus of the rest of the body.

The course of the disease, which tends to recur from time to time, is destructive to the nutrition of the conjunctiva, and later to the cornea. The former undergoes cicatricial change, and may grow fast to the ball; the latter becomes opaque and staphylomatous.

Under the name *Essential Shrinking of the Conjunctiva*, a condition of atrophy, contraction and gradual disappearance of the conjunctival cul-de-sac has been described, during which the free borders of the lids become fixed to the ball and the cornea becomes dry and opaque. This probably is a form of pemphigus, but has also been recorded as an essentially distinct process.

These appearances must not be mistaken for granular lids, with which they have no association.

Treatment.—It has been attempted to keep the conjunctiva moist with glycerine, and rabbit's conjunctiva has been transplanted, but without results.

Injuries of the Conjunctiva.—(a) *Foreign Bodies.*—A small particle of coal, ash, or dust is easily removed, if lodged upon the lower portion of the conjunctiva; but if it finds its way beneath the upper lid, and is situated far back under the retrotarsal fold, it may not come into view when the lid is everted, unless the fold is pushed into prominence. If the foreign body is attached to the tissues, it may be necessary to dislodge it with the point of a needle, or with a spud. Cocaine will render this operation painless.

(b) *Wounds.*—These may be part of a serious injury involving the lid or deeper structures of the eye; more rarely, they occur as simple lacerations, confined usually to the bulbar portion. In suitable cases, after proper cleansing, the lips of the wound should be drawn together with a few sutures.

(c) *Burns.*—These are commonly inflicted with acids or unslaked lime, and are especially serious because of the deformity which the subsequent contraction is likely to produce, or on account of the development of a symblepharon (page 207).

If the substance is lime, all the particles must be removed at once, and this is best accomplished by flooding the eye with water from a spigot; if an acid, this may be neutralized with a weak alkali. The subsequent treatment calls for the instillation of olive or castor oil, and atropine drops, to prevent secondary iritis if the cornea is much inflamed; the latter drug may be incorporated with liquid vaseline and placed in the cul-de-sac.

Affections of the Caruncle.—The caruncle and semilunar fold may be swollen in conjunction with a general inflammation of the conjunctiva, but also may undergo localized enlargement and inflammation, to which the name *encanthis* has been applied, and which is subdivided by systematic writers into an *acute*, or *inflammatory*, and a *chronic* variety. The process may go on to the formation of a minute abscess.

Swollen caruncles are commonly found in patients with eye-

strain, especially with imperfect amplitude of convergence. The small body is red, elevated, and angry-looking, and injected vessels run from it towards the cornea in the inter-palpebral space. This condition might be designated *symptomatic*, or *functional encanthis.*

In like manner, temporary irritation of the structure is caused by the lodgment upon it of a foreign body, or by the presence of misplaced cilia which rub against it. This caruncle should be carefully examined when patients complain of irritation, lachrymation, and inability to use their eyes with comfort.

The excessive development of the hairs normally placed upon the caruncle, is called *trichosis caruncul*æ.

A few examples of tumors situated upon and growing from the caruncle have been recorded; in two instances, the growth proved to be an adenoma (Prudden and Schirmer).

Treatment.—Local irritations of this body may be relieved by the direct application of a mild astringent like alum, or soothed by touching it with tincture of opium. Foreign bodies, stiff hairs, and misplaced cilia must be extracted. A tumor is to be removed by the ordinary method of excision.

CHAPTER VII.

DISEASES OF THE CORNEA.

Under the general term *keratitis* are included the divers forms of inflammatory affections of the cornea, to which, according to the type, certain well-marked stages belong: cellular *infiltration* in the layers of the cornea going on either to absorption, or to the formation of pus; loss of the substance of the cornea lying over the infiltrated area, and the development of an *ulcer;* loss of the transparency of the superficial corneal layers over an infiltrated area, which has been converted into pus and created an *abscess*, with the final destruction of these layers by future development of the abscess; the appearance of *vessels in the cornea;* and the process of *repair* after loss of substance, or the period of *cicatrization.*

Certain associated and subjective symptoms may be present in all forms of corneal inflammation. Among the former the most notable are the congestion of the vessels of the circum-corneal area; the possible involvement of the iris and ciliary body in the severe types of the affection, with the added signs of iritis; and the development of pus in the anterior chamber. The subjective symptoms include diminution of vision, pain, photophobia, excessive lachrymation, and blepharospasm.

Although it is customary to divide the many types of corneal inflammation into suitable groups, it is by no means possible to refer the disease in each instance to one or other of these divisions.

Phlyctenular Keratitis.—This disease is characterized by the formation of single or multiple vesicles or pustules on some portion of the cornea, and is accompanied by dread of light and blepharospasm.

Causes.—The disease is quite constantly seen in strumous subjects, rarely before the first year of life, most frequently in children near the age of puberty, and less commonly in adults.

The ordinary symptoms of struma may be present—enlarged lymphatic glands, prominent and swollen lips, and diseases of the joints and bones.

This form of keratitis is in close connection with obstructive and inflammatory diseases of the nasal passages, and an irritating rhinitis is a constantly associated disorder, which, in turn, determines an eczema about the nares. The affection often follows in the wake of measles or other acute exanthemata, and is distinctly under the influence of climate, being aggravated in warm and moist weather.

Micro-organisms, which resemble the coccus flavus desidens, have been described with phlyctenular keratitis.

In the belief of some authors, astigmatism bears a relation to its development.

Symptoms.—The phlyctenules, which consist in the early stage of minute subepithelial collections of round cells, appear upon the cornea usually at or near the corneo-scleral junction. They vary in size from a poppy-seed to a millet-seed; their tops, at first gray, speedily grow yellow, break down, and form superficial ulcers. They are accompanied by decided local congestion, increased lachrymation, and photophobia.

The palpebral conjunctiva, always hyperæmic, may remain translucent and bathed in tears, or the disorder is not infrequently accompanied by muco-purulent ophthalmia.

When the photophobia is severe, the child buries its head deeply in the bedclothes; the lids are spasmodically closed, rendering inspection of the eye difficult, at times well-nigh impossible. The dread of light and the blepharospasm are probably due to direct irritation of the corneal nerves, as Iwanoff found the cellular infiltration situated along the course of the nerves.

The pustule, when it breaks down, forms the *phlyctenular ulcer.*

This may remain at its original seat near the margin, or creep towards the centre of the cornea, followed by a bundle of thickly-crowded bloodvessels and form a special type of corneal inflammation known as *fascicular keratitis.* The bloodvessels, when the ulcer heals, disappear, but a stripe of opacity remains.

Under the name *marginal keratitis* a variety of this disorder

exists, characterized by the development of numerous phlyctenules along the rim of the cornea, giving rise to a process which may cease here, or which by further invasion may produce vascular ulcers.

More dangerous than any of the other varieties is the formation of a *single pustule*, just at the corneal border, which speedily ulcerates and is surrounded by a yellow area of infiltration, with a strong tendency to perforate.

If these inflammations recur constantly, the cornea becomes clouded, uneven from loss of epithelium, and covered by numerous superficial vessels, the whole forming the so-called *phlyctenular pannus*.

Diagnosis.—This presents no difficulties, direct inspection rendering the nature of the disease evident.

Prognosis.—The course varies greatly; in mild cases healing takes place with only a slight loss of substance, and the resulting scar is scarcely discernible.

Not so with the severe forms, in which there has been decided loss of substance, and a distinct scar-tissue remains, or in which deep ulceration with perforation occurs, or where constantly recurring vascular ulceration leaves an uneven and roughened surface. In children of the strumous type, especially if their surroundings are unfavorable, phlyctenular keratitis is exceedingly intractable.

Treatment.—In order to make a thorough application of the local remedies, the child's head should be taken between the surgeon's knees, and the lids separated, while the attendant holds the hands and body; the cornea will usually roll out of sight, but gradually may be coaxed into view. Sometimes a lid-elevator is useful, and a few whiffs of ether or of chloroform may be necessary.

If much secretion is present, boric acid solution is to be employed. Atropine drops should be instilled with sufficient frequency to maintain mydriasis. Cocaine, judiciously used, will allay the photophobia, but its continuous application when corneal ulcers exist is to be deprecated. Later, an ointment of the yellow oxide of mercury (gr. i–℥j), either with or without the addition of atropine, may be employed, or calomel may be dusted

into the conjunctival sac, provided no form of iodine is being exhibited. The eyes should be protected with goggles, and the child encouraged not to bury its head in the bedclothes.

Douching the eyes with cold water will subdue the dread of light, and touching the ulcerated external commissure, which almost invariably exists in these cases, with a crystal of bluestone, as Koller has suggested, helps to relieve the blepharospasm. In severe cases the ulcerated fissure may be incised, or the lids may be forcibly separated. No doubt this acts by stretching or rupturing a few fibres at the commissural angle, and relieves the spasm in the same manner as a similar manipulation is efficacious in fissure of the anus.

The best possible hygienic surroundings must be obtained, with fresh air and wholesome food. Cod-liver oil, iron, quinine, often suitably given with pepsin, and arsenic, are the most acceptable internal remedies.

The urine should be examined in all these cases; and scrupulous attention to the condition of the alimentary canal is an important factor in the treatment.

If rhinitis is present, a powder composed of equal parts of pulverized camphor, boric acid, and subnitrate of bismuth is useful (Augagneur), especially if the parts are thoroughly cleansed with Dobell's solution before its insufflation into the nasal chambers. In obstructive post-pharyngeal and nasal affections (hypertrophies, adenoid vegetations), these mild measures are not sufficient, and the diseased areas must be treated on the principles of intra-nasal surgery.

In stubborn forms of recurring vascular ulcer and deep ulceration, especially in the fascicular type, the use of the actual cautery in the manner later described, is productive of excellent results.

After healing, provided the condition of the cornea permits it, any refractive error should be corrected. There is reason to believe that astigmatism may play some rôle in the production of keratitis in children; hence its correction in patients constitutionally predisposed to this disease, even at a very early age, is a suitable prophylactic measure.

In general terms phlyctenular inflammation of the cornea,

which has just been described, is a circumscribed, usually superficial keratitis, and is known under a variety of synonyms—lymphatic, scrofulous, vesicular, fascicular, and pustular—and when it appears in adults, assumes the form of a simple corneal infiltration. It furnishes the greatest number of ulcers of the cornea which are found in early life, and also a large group of those ulcers which are of *primary* origin, *i. e.*, where the disease starts in the cornea, the remainder of the group being caused by injury, abscess, depressed nutrition, etc. The entire series is in contrast to *secondary* ulcers, *i. e.*, when the disease follows as the result of a severe inflammation of the conjunctiva, *e. g.*, purulent, diphtheritic, or granular ophthalmia.

The remaining inflammations of the cornea are divided by systematic writers into *ulcerative* and *non-ulcerative* inflammations.

Ulcers of the Cornea occur when the stage of infiltration has failed to terminate in absorption, and the overlying corneal layers have become disintegrated, with the formation of an open lesion.

In addition to those which have been described with phlyctenular keratitis, corneal ulcers may be gathered into several groups :—

1. *Simple ulcer* appears in the form of a small, superficial, gray lesion, associated with slight pericorneal vascularity, and results from the rupture of a phlyctenule ("pimple ulcer"), or from trauma.

An ulcer, which from its situation is called *small central ulcer*, appears as a gray or gray-white opacity in the centre of the cornea, and is not accompanied with much vascularity or dread of light. The elevation is slightly cone-shaped until the whitish top breaks down into a shallow depression.

Usually single, this form of ulcer may be multiple, and under any circumstances tends to recur. It is seen in young children who have been poorly nourished, and are of a strumous habit. While healing generally occurs with promptness, the tendency to recurrence leaves permanent opacity, which from its central situation, may seriously impair vision. If neglected, and in patients of poor nutrition, this ulcer occasionally forms an abscess

of the cornea, or changes its type and develops into the following variety :—

2. *Purulent or deep ulcer* consists of an area of yellowish (purulent) infiltration, surrounded by a zone of hazy cornea, round or irregular in shape, centrally excavated, and with a tendency to travel inward toward perforation, but not to extend in a lateral direction. Like all severe types of corneal ulceration, it may be associated with inflammation of the iris and the formation of pus in the anterior chamber; if perforation takes place, an adherent scar or leucoma results.

This ulcer is either *primary* from injury, and sometimes contains a foreign body as its nucleus, or it may be *secondary* to a violent grade of conjunctival inflammation. The subjective symptoms are pain, browache, congestion, and sometimes, though not necessarily, photophobia.

3. *Indolent ulcer* (*absorption ulcer*) occurs under several forms: (a) *Shallow central ulcer*, with slightly turbid base, unattended with any considerable pain or photophobia, essentially chronic in its course, and healing finally with a faintly opaque remaining facet (*facetted ulcer*).

(b) *Excavated or gouged-out ulcer*, often seen in children, most troublesome because it is so rebellious to treatment, has its seat near the corneal margin. It may be entirely overlooked on account of the absence of congestion, and because in appearance, it is a small punched-out excavation with transparent bottom, and free from any opaque surrounding. The floor of the ulcer loses its translucency when healing is about to take place, and a few vessels of repair pass to its margin.

(c) *Reparative ulcers* are seen when, as occasionally occurs, in the course of the healing of an ordinary corneal ulcer, this loses its turbidity and assumes a clear facet-like appearance. These are similar to the absorption ulcers which occur primarily, and which, unattended with injection and with local symptoms, may none the less extend inward and perforate the cornea.

Indolent ulcers, in general terms depend upon some failure in the nutrition of the cornea, due to nervous disturbance. They are found in anæmic and scrofulous subjects, and are seen in cases of chronic trachoma.

4. *Infecting or sloughing ulcer* (*purulent keratitis*).—Ulcers unattended by vessels of repair, which spread widely from one border and readily become complicated with hypopyon and iritis, and which are often the result of a trifling injury, usually affect elderly people and those whose nutrition is depressed.

The most important type of these is the *acute serpiginous or creeping ulcer* of Saemisch. In the beginning a nearly central gray area forms, which ulcerates; its margins are sharp, and one, assuming the form of an elevated curve, is more decidedly opaque or yellow than the others, and is known as the *arc of propagation*. Immediately behind it, the ulcer with its gray floor seems deeper than the portion next to the corneal margin.

The surrounding cornea is opaque, and the lesion spreads rapidly, at the same time growing deeper; iritis, irido-cyclitis, and hypopyon ensue, and perforation and extensive sloughing of the cornea are likely to occur. Usually the patient complains of severe brow pain, and the eye is intensely tender. Vision is reduced to mere light perception. In other cases, while the local lesion is severe, the subjective symptoms of inflammation are almost absent.

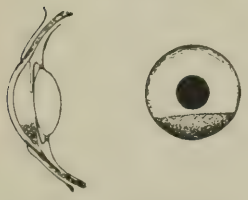
Cause.—A sloughing ulcer of this character depends upon local infection, and most frequently results from an injury to the cornea from a chip of stone, a chestnut burr, beard of wheat or the like, which may cause an insignificant wound, but which, in an individual not disposed to kind healing, may terminate, through microbic infection (probably a special fungus), in this dangerous form of inflammation. This becomes more likely if the patient suffers at the time of the injury from catarrh of the lachrymal sac or from chronic conjunctivitis, the micro-organism being contained in the unhealthy secretion. The most marked types of this disease are seen in laborers in the harvest season.

Hypopyon, to which reference has been made, may be seen with both small and large ulcers, and consists of a collection of pus in the anterior chamber, varying in extent from a mere line to a quantity which well-nigh fills the chamber.

This appears as a yellow mass at the bottom of the anterior chamber, and is bounded above by horizontal margin. If the collection is fluid, its position will shift with movements of the

head; if it is tenacious, no movement can be observed. The pus is caused by an aggregation of leucocytes, derived in part from the corneal disease, and in part from the iris, which is also inflamed.[1]

Fig. 89.



Hypopyon or a collection of pus in the anterior chamber.

The combination of ulcer of the cornea and pus in the anterior chamber has received the name *hypopyon-keratitis*, which generally is limited to the type described as infective or creeping ulcer.

5. *Abscess of the cornea* consists of a purulent infiltration in the deeper layers of this membrane, over the centre of which, in the early stages, the epithelium is unbroken and prominent, but later, discolored and slightly sunken.

The corneal zone immediately surrounding it is hazy. The margins of the collection are thicker and more prominent than its middle; pus is seen in the anterior chamber; the aqueous humor is turbid, and the iris inflamed.

The subjective symptoms of severe corneal disease are commonly present, but, as with sloughing ulcers, these indications may be absent.

If the abscess is deep, the process may terminate without rupture of the upper layers and the formation of an open lesion, but generally it grows more yellow, notches laterally, bulges forward and finally bursts, leaving a more or less ragged ulcer covered with tenacious pus, and pursuing a course similar to or identical with that described under sloughing or infecting ulcer, of which, indeed, abscess is the first stage. It will hence be seen that abscess of the cornea, according to its stage, may belong to the non-ulcerative or ulcerative lesions of the cornea.

Causes.—Abscess of the cornea results from an inoculation of the affected area with the pathogenic micro-organisms which are the cause of suppuration, these having gained entrance through

[1] Onyx, a term frequently applied to a supposed accumulation of pus between the layers of the cornea, and settling in its most dependent portion below an abscess, should not be retained, as it describes an appearance which is incorrectly interpreted (Berry).

an abrasion in the epithelial cells. As already stated, simple ulcers, through neglect, may form abscesses; and they follow slight traumata when the latter become infected, especially by unhealthy lachrymal secretion, and are seen in association with violent types of conjunctival inflammation. A certain number of cases have been ascribed to cold; in still others no definite cause can be ascertained.

A variety of abscess of the cornea, non-inflammatory in character, without any healing tendency, and with an entire absence of subjective symptoms, has been described as occurring in scrofulous children under eight years of age. The character of the disease and the constitution of its subjects have led some to consider it a form of *tuberculosis of the cornea.*

Most violent forms of *suppurative keratitis* occur during the convalescent stages of smallpox, though pustules rarely form upon the cornea. Abscess of the cornea occasionally accompanies scarlet fever, measles, typhoid and typhus fever, and in these cases must be regarded as metastatic, the pathogenic material having been conveyed through the blood, and not as coming from without, as in the more usual examples.

6. *Ulcus rodens* is the name applied by Mooren to a *creeping ulcer* which begins at the upper edge of the cornea as a superficial lesion, separated from the healthy portion by a gray, opaque rim, which is undermined. Although vessels may pass to it and cicatrization apparently begin, it relapses quickly and progresses forward, until the whole cornea has been traversed and sight is destroyed. The cornea is not perforated in this disease, which is a rare form, attacking elderly and depressed subjects.

7. *Circular ulcer* (*marginal ring ulcer*, *annular ulcer*) occurs in the form of a deep groove, at the corneal margin, unaccompanied by much infiltration, which gradually progresses until it may entirely girdle the cornea and cut it off from its nutrition. Photophobia, injection, lachrymation, and other irritative symptoms are not prominent, but perforation of the cornea and prolapse of the iris are common. The disease is seen in debilitated subjects.

Another variety of *ring ulcer* is formed as the result of a *marginal phlyctenular keratitis* (page 260), probably by the coa-

lescence of a number of small foci. Ring ulcers are also seen in catarrhal and purulent ophthalmia, and in the latter condition may prove especially dangerous if they are hidden by the chemotic conjunctiva.

8. *Dendriform ulcers* (*keratitis dendritica ulcerans mycotica, furrow-keratitis, kératite ulcéreuse en sillons étoiles*) are a form of keratitis probably dependent upon a special micro-organism, and appear in branch-like ramifications, having a superficial situation, with slight, knob-like swellings at the end of the branches. The inflammation manifests itself in two forms.

In one, from the beginning, the symptoms include photophobia, lachrymation, strong bulbar injection, swelling of the upper lids, and absence of the epithelium over the furrow-formed ramifications—an implantation of the process in the deeper corneal layers.

In the other, the disease assumes a subacute or torpid character, with practical absence of severe irritative symptoms and loss of the covering epithelium—a limitation of the lesion to the superficial layer. In the first form the opacity is confined to the axis of the furrows; in the second, to the border. After healing, the scars have the same general configuration which was present during the stage of ulceration. The disease is rare and occurs in both sexes.

The *cause*, further than its probable mycotic nature, is unknown. Fuchs thinks some cases may arise from febrile herpes of the cornea (page 281), by the increase and coalescence of the small blebs. Malaria originates a keratitis in which the lesion consists of a peculiar, narrow, serpiginous, superficial ulcer, with lateral offshoots, like the skeleton of veins in a lanceolate leaf, usually accompanied with photophobia and lachrymation, and sometimes ushered in with severe supra-orbital neuralgia (Kipp).[1]

[1] It will be observed that several varieties of corneal ulcers have one symptom in common, that of creeping across the corneal surface from their points of origin, viz., fascicular keratitis ("snail-track ulcer"), Saemisch's ulcer, rodent ulcer, and dendriform ulcers, and for this reason they may all be grouped under the general term, serpiginous ulcers, as suggested by Fuchs. Ring ulcers possess somewhat the same peculiarity exercised in a circular manner.

9. *Exhaustion-ulcer* (*kerato-malacia*) may appear as an extensive ulceration in the centre of the cornea, or as a ring-abscess at its circumference. The tissue speedily is converted into a slough, which drops out, and an extensive perforation results.

In other instances the sequel is described as a species of *atrophy of the cornea*, which is converted into a whitish, flattened plate (Schmidt-Rimpler).

One or both corneæ may be affected, and the usual cause is exhaustion after acute illness, or after prolonged diarrhœa or dysentery. A similar softening and sloughing of the cornea may be the result of ophthalmia neonatorum (page 223), or cataract operations which have become septic, and they are seen in a perfect type in xerotic keratitis (page 279).

Treatment of Ulcers of the Cornea.—It is not possible to lay down definite rules for the treatment of all forms of corneal ulceration—this must be governed by the exigencies of each case; but certain principles are common to the various types.

Acute stage: Pain and photophobia.—These should be relieved by the plans already suggested in treating phlyctenular keratitis. In mild cases, atropine, a lotion of boric acid, and dark glasses will usually suffice. The use of blisters and setons, recommended in chronic cases, is seldom required, but a leech to the temple in sthenic types may be needed.

Cocaine will relieve photophobia temporarily, but its *continuous use in corneal ulceration is positively harmful.* If a corneal ulcer is accompanied by much dread of light, the methods described under phlyctenular keratitis may be employed.

Whenever corneal ulceration is accompanied by conjunctivitis and discharge, the inner surfaces of the lids should be brushed over with a weak solution of nitrate of silver (2–5 grains to the ounce), and the cul-de-sac carefully cleansed with a boric acid solution, or the collyrium of bichloride of mercury, as often as necessary to free the eye from accumulated secretion.

Subacute and Torpid Stage.—After the subsidence of the acute symptoms, or when the ulcer from the beginning is unaccompanied by these, local stimulation should be practised. This is

best done with an ointment of the yellow oxide of mercury prepared by the following formula:—

Yellow oxide of mercury	1 grain
Sulphate of atropine	¼ grain
Vaseline	1 drachm

A small portion to be introduced between the lids night and morning.

The atropine maintains the mydriasis and at the same time is sedative. When these actions are no longer needed, the atropine may be omitted from the salve, and the mercurial compound alone employed. Finely powdered calomel dusted into the eye is also of excellent repute. In like manner iodoform or aristol, in salve or powder, may be tried. Direct stimulation with a probe dipped in laudanum, or a weak solution of nitrate of silver (five grains to the ounce), is a useful procedure, either to encourage the healing of an ulcer which has passed into the subacute stage, or to excite curative reaction in one that has been torpid from its origin. Eserine is indicated, instead of atropine, in small sluggish ulcers, unattended by active symptoms.

Deep and Sloughing Ulcers.—It was a universal, and is still a quite common practice, to instil *atropine* drops, because of their anodyne effect, and because they lessen the liability to iritis, mitigating at the same time the severity of the inflammation, through their power to contract the vessels of the ciliary region, and diminish the supply of nutritive material to the cornea.

In many cases, however, *eserine* is the better drug, either because it has the power of stopping the migration of white blood corpuscles, or because it promotes absorption through dilatation of the ciliary vessels, or acts locally upon the ulceration, limiting the sloughing process. Furthermore, abnormal intraocular tension is lowered by the action of the drug. The strength of the solution may be from one-quarter to one grain to the ounce, the latter being unnecessarily active in most cases. Deep ulcers near the margin are those most suited for its application. One or two drops of the eserine solution should be instilled from three to six times daily, and, as under its influence, congestion of the ciliary body and iris may ensue, as well as brow pain, these may be counteracted by using a few drops of the atropine lotion at night. The combination of the drugs thus employed in cases

where no iritic complications are present, is productive of the most happy results. Instead of eserine, pilocarpine (gr. ½–2 grains to the ounce), has been used.

Pain is relieved and the process of repair encouraged by the frequent application of *hot compresses* in the manner already described (page 225). During all this time the cul-de-sac must be irrigated frequently with *antiseptic collyria*—a saturated solution of boric acid, or bichloride of mercury (1-10,000).

(a) *Impending Perforation.*—When perforation of the cornea is liable to occur by extension of the ulcer, an antiseptic compressing bandage should be applied, and removed when the necessary local applications are made, and again reapplied. Long-continued use of the bandage is often followed by the appearance of an eczematous eruption upon the skin of the lids. This should be treated by dusting the parts with calomel. Catarrh of the conjunctiva contraindicates the use of the bandage unless the danger of perforation is at hand.

If bulging forward of the floor of the ulcer indicates that perforation is imminent, the intraocular tension should be lessened by paracentesis of the cornea. This operation is described on page 587. After its performance, eserine is instilled, if the ulcer has a peripheral situation, atropine, if it is central; the bandage is reapplied and the patient placed at rest. It may be necessary to repeat the operation on several days. Intense pain will often be thus speedily relieved and healing rapidly result.

(b) *The Spread of Local Infection.*—If in spite of such treatment the corneal ulcer continues to spread, either in the form of a lesion creeping across the face of the cornea, or by passing inward through its layers, the process must be stopped by one of several means: (1) Scraping with a curette; (2) the direct application of a suitable chemical which combines the properties of a germicide and a caustic; and (3) the actual cautery.

(1) The ulcer may be cautiously curetted with a sharp spoon or a spud, all the sloughed material removed, the edges pencilled with a sublimate solution (1-2000), and iodoform dusted upon its surface.

(2) The chemical substances commonly employed are nitrate of silver or carbolic acid. The former, in the strength of ten to

twenty grains to the ounce, is applied directly to the seat of ulceration (care being taken to avoid the surrounding cornea), by means of a probe on which has been twisted a thin band of absorbing cotton, or the point of a pencil of lunar caustic may be gently pressed against the sloughing tissue. Carbolic acid (liquid) may be employed in the same manner as the silver solution.

(3) The actual cautery may be either a small Paquelin or galvano-cautery; when neither of these is at hand, a knitting needle or platinum probe, heated red hot in the flame of a Bunsen burner, will suffice. The edge and floor of the ulcer should be gently but thoroughly burned. If the ulcer is very deep, its floor may be perforated with the point of the cautery. Usually one cauterization is sufficient, but in the event of failure to destroy all the sloughing material, the operation should be repeated on the following day. (See also page 587.) Cocaine renders the operation painless, but there is no objection to general anæsthesia in nervous patients.

If the surgeon is careful to touch only those portions involved in the ulcerated process, the resulting scar will not be greater than would have been the case had the ulcer secured cicatrization without such treatment. Fluorescin will show the extent of the ulcer, and mark out the area to be cauterized.

The actual cautery is indicated in all sloughing ulcers which fail to show improvement after milder measures have been tried, and in torpid or relapsing ulcers, without much reaction, where a decided stimulant is needed. In certain types of infecting ulcers, of serpiginous character, typified by Saemisch's ulcer, and also in annular ulcer and the furrow-keratitis, where the apparent local infection is less marked, the actual cautery is the most potent agent to arrest the process. In rodent ulcer it is one of the few means that are at all efficacious.

Abscess and Hypopyon.—The pus should be evacuated. If the abscess is unbroken, its anterior wall may be incised with a delicate knife, and the subsequent treatment conducted on the principles laid down for sloughing ulcers. If the abscess has burst, and is complicated with hypopyon, the latter may be encouraged to absorption by paracentesis of the cornea in its lower

portion, or by the more formal procedure of Saemisch, in which a section is made directly through the diseased area (page 588).

The use of the actual cautery has to a great degree replaced the operation of Saemisch, and in many instances absorption of the products of a hypopyon-keratitis will follow the non-operative treatment already described.

Perforation.—If perforation occurs, the vigorous use of atropine or eserine, according as the lesion has a central or peripheral situation, aided by gentle efforts at *reposition* with a probe, a compressing bandage, and rest in the recumbent posture are the first measures.

In the event of failure, or in any event, if the prolapse is a large one, the iris should be drawn forward through the aperture and excised close to the cornea, provided not more than two or three days have elapsed since the accident. After excision, the aperture may be covered with a conjunctival flap taken from the bulbar conjunctiva, twice as large as the original opening, into which it is gently inserted with a probe. A firm compressing bandage, not to be disturbed for three days, is then applied. This method is said by the author, Gamo Pinto, to secure a flat cicatrix, often without any attachment of the iris, although anterior synechia usually results even from the smallest perforation. If the prolapse has been large, a more or less complete staphyloma will follow in spite of vigorous bandaging and the use of eserine or atropine.

Résumé of the Local Measures.—The most useful antiseptics during corneal ulceration are boric acid (gr. xv–℥j), bichloride of mercury (1-8000 or 1-10,000), and iodoform in salve or powder. For the latter drug may be substituted iodol and aristol, which, however, do not seem to surpass it in beneficial results. Chlorine water, in half strength, is much employed by some surgeons.

Of the local measures to stimulate healing in sluggish ulcers, or to hasten the process of repair, laudanum directly applied or in the form of a collyrium, and yellow oxide of mercury in salve (Pagenstecher's salve), are most commonly employed. The latter remedy may be replaced by an ointment of iodide of potash, iodol, aristol, or iodoform, or by oleum cinereum (Lang), which consists

of metallic mercury suspended as finely as possible in lanolin and almond oil.

The aniline dyes, in the form of blue and yellow pyoktanin, have been recommended in corneal ulceration by their author, but Stilling's results have not met with general acceptance. In fact, positive harm has resulted in some instances.

The indications for a mydriatic or a myotic have been given. If for any reason (idiosyncrasy) atropine is not tolerated, mydriasis may be maintained with hyoscyamine or daturine; and if eserine creates irritation, pilocarpine in double the strength may be tried. It is important to remember that cocaine has no place in the treatment of corneal ulcers, save only as a temporary remedy, for example, to produce anæsthesia preparatory to operation, or to remove a foreign body. Its continued use will increase the ulceration.

Of the methods described to stop the spread of infecting ulcers, curetting or touching with nitrate of silver is the most generally applicable, unless the conditions are present which are believed to demand the actual cautery.

Associated Conditions.—The treatment of conjunctivitis complicating ulcer of the cornea, in no wise differs from that suited to ordinary ophthalmias. An ulcer should always be carefully examined for the presence of a *foreign body*, which may be covered by a small slough, while *misplaced cilia* are fruitful sources of corneal irritation and may hinder the prompt healing of ulcers. They should be removed with epilating forceps, or destroyed by galvano-puncture.

The *lachrymal passages* should be explored, and if strictured, rendered patent, while irrigation of the lachrymal canal with a four per cent. solution of boric acid, or 1-8000 solution of bichloride of mercury, is of material aid in the treatment of infecting ulcers, because this passage is commonly the seat of unhealthy secretion. At the same time the naso-pharynx needs exploration and treatment of diseased conditions.

The *teeth* should always be examined, and if faulty, the case turned over to a competent dentist. The frequent relation of carious teeth to corneal ulceration is well established, and the irritation of a new dentition in young children has been found

to be the cause of abscess or ulcer of the cornea. In brief, the entire *cephalic mucous membrane* (Harrison Allen) should be explored, because, in one or other of its component parts, it may be the seat of disease, which, even if it is not the cause of the co-existing corneal ulceration, is none the less responsible for retardation in the healing process.

Constitutional Treatment.—Hygiene, diet, and judicious internal medication are of paramount importance. The patient should not be secluded in a dark room, but, with eyes properly protected with goggles, go out into the fresh air every day. The diet must be nutritious and easily digested; tea, coffee, candies, and pastries are to be forbidden.

If struma is present, cod-liver oil, lacto-phosphate of lime, and iodide of iron or syrup of hydriodic acid are indicated; anæmia is best treated with the tincture of the chloride of iron or with the carbonate of iron; any suspicion of malaria requires the use of quinine and arsenic. The syphilitic taint, which may be present without being the direct cause of the ulcer, indicates the iodides, and mercury, especially in the form of the bichloride. As gout has been shown to be the cause of some corneal ulcers, this, as well as the rheumatic dyscrasia, must be searched for, not alone as an active manifestation, but also as a hereditary disease, and suitable remedies exhibited: citrate of lithium, mineral waters, iodides, colchicum, salicylic acid, salol, etc.

A very strict inquiry into the condition of the alimentary canal should never be forgotten, as this may not be in a condition properly to receive the tonics which are indicated. In children, calomel is a useful laxative; in older patients, the salines and saline waters are often necessary.

The urine should be carefully examined for albumin and sugar, and for the products which indicate imperfect assimilation.

A very important element in the successful management of cases of sloughing ulcers, especially in subjects of depressed nutrition, is the maintenance of proper circulation. This seems best secured by the exhibition of brandy or whiskey in milk, and of strychnine or digitalis as a vaso-motor or cardiac tonic. Severe pain may be alleviated by opium or morphine in suitable

cases; the drug also has a favorable influence upon the ulceration. Antipyrine may also be used for its analgesic effect.

Results of Corneal Ulceration.—Opacities more or less permanent follow all ulcerations of the cornea. If the opacity is slight, it is spoken of as a *nebula* or *macula;* if dense, as a *leucoma.*

It is evident that upon the position of the opacity in the cornea depends its influence upon vision. The more central it is, or rather the more directly it encroaches upon the pupillary region, the greater will be the disturbance of direct vision. Inequalities in the curvature of the cornea distort the retinal images, and are fruitful sources of irregular astigmatism.

When perforation has followed ulceration and the iris has remained entangled in the aperture, the attachment is called an *anterior synechia;* the corneal scar to which the iris is fastened, receives the name *adherent leucoma.* An eye thus afflicted may become quiet and retain, either with or without operative interference, useful vision; but may also be a continual source of annoyance, subject to recurring attacks of inflammation, and may originate sympathetic irritation in the fellow eye.

Fig. 90.



Complete staphyloma of the cornea.

The distension of a cicatrix, to whose inner surface the iris is attached, constitutes a *corneal staphyloma*, which is called *total*, when the entire cornea is involved, *partial*, when only a portion

is included, and *racemose*, when perforations have occurred at various points.

The mechanism of the development of staphyloma is briefly as follows: A perforation takes place, and the iris falls forward and attaches itself to the opening, or protrudes through it, becoming fixed there by the lymph thrown out in the process of repair. The scar tissue which remains fails to withstand the intra-ocular tension, and that portion of the cornea is pushed forward beyond its normal limits, forming a pouch-like deformity. (Fig. 91.)

Fig. 91.



Partial staphyloma of cornea, showing the attachment of the iris to its inner surface (Meyer).

The protrusion may flatten down, and under the influence of fresh inflammation bulge forward again, or may extend between the palpebral fissures and prevent the lids from closing (consult Fig. 90). Staphylomata, the result of ulceration, are more or less opaque, because they represent the scar tissue which has formed after the rupture of the membrane. Corneal staphylomata, which are not opaque and have not formed under the influence of an inflammation, also occur, and will presently be described.

If after inflammation of the cornea, with loss of its superficial layers, the intraocular pressure bulges forward the remaining lamina into an opaque elevation, the condition is called *kerectasia*. This differs from an ordinary partial staphyloma because there has been no perforation, and the iris tissue is not involved in the process.

If all the layers of the cornea down to the posterior elastic lamina are destroyed, and this protrudes through the opening in a small, translucent hernia-like pouch, surrounded by a rim of opaque cornea, it is known as a *keratocele*.

An orifice remaining after a wound, or more commonly because of the failure of an ulcer to heal, is designated *fistula of the cornea*. It may last for a long period and stubbornly resist efforts at cure. It has been recommended to touch the mouth of the fistula with a point of lunar caustic, and even to pare the edges and introduce a corneal suture.

Treatment of the Results of Corneal Ulceration.—Satisfactory results follow *massage of the cornea*. The massage movements should be made in a circular and radial manner, over the cornea, through the closed lids, after the introduction of a small piece of the yellow-oxide-of-mercury salve, into the conjunctival cul-de-sac. Some irritation accompanies the method, but may be allayed by the occasional use of a collyrium of boric acid and cocaine.

Recently Alleman has revived the use of *galvanism* for the removal of corneal scars. A suitably prepared electrode is connected with a battery, the cathode being applied directly to the anæsthetized surface of the cornea, and the anode to the soft tissues of the cheek. Usually a current of from one to one and one-fourth milliampères gives the best results. The *séance* lasts at the beginning for one minute at a time, and is gradually increased to three and four minutes. Great care should be taken not to produce too much reaction. The author reports very favorable results.

Dense leucomas cannot be influenced by the practice of massage. A sufficient number of cases treated by galvanism have not been reported to determine its value. Vision may be improved by an iridectomy for new pupil, and the appearance of the eye, by tattooing the cornea with India ink. In recent times attempts have been made at transplantation of rabbit's cornea for the relief of dense central opacities, but although Von Hippel, the originator of the operation, has reported some instances in which he was encouraged, the method does not seem likely to meet with universal success.

The treatment of staphyloma in the first place is preventive, and those measures already described in connection with impending perforation, and perforation after its establishment, are indi-

cated, namely, a compressing bandage and the use of eserine, or, under some circumstances, atropine. If in spite of this the bulging continues, paracentesis of the anterior chamber, or an iridectomy opposite the clearest part of the cornea, may be performed. If the disease has been so extensive that a complete and unsightly staphyloma has formed, which is the seat of pain and a source of danger to the fellow eye, excision of the globe is indicated, or one of the various substitutes for the operation of enucleation.

Xerotic Keratitis (*Kerato-malacia, Necrosis Corneæ, Infantile Ulceration of the Cornea, with Xerosis of the Conjunctiva.*)—This disease is characterized by a dryness of the conjunctiva and a destructive ulceration of the cornea, and usually appears in infants during the first year of life.

Cause.—Formerly the disease was believed to be dependent upon encephalitis, a theory no longer tenable. It occurs only in anæmic, badly nourished individuals. It has been seen accompanying measles and variola, and among children with diarrhœa, and those who are inmates of homes whose surroundings are bad. Bacilli have been found, but the special microbe, if it exists, has not been isolated. The disease is not a common one. A somewhat similar condition has been described in the eyes of negro children in the south (Kollock).

Symptoms.—In the beginning there are conjunctival congestion and lachrymation, but the peculiarity of the disorder is the development of the appearances described under epithelial xerosis (page 250), in connection with the corneal lesions A gray haze, rapidly turning into ulceration, appears in the cornea, followed by inflammation of the iris, and the formation of hypopyon. Perforation of the cornea, and destruction of the eyeball, may result. Both eyes as a rule are affected, one earlier than the other.

The *prognosis* is very unfavorable; the patients usually die of the wasting disease which has occasioned the trouble, or of an intercurrent pneumonia. In one case streptococci were found in the local lesions, and foci of these micrococci scattered throughout the body.

Treatment.—This resolves itself, besides the ordinary treatment of severe corneal ulceration, into the administration of the internal remedies which are indicated by the general state of the patient.

Neuroparalytic Keratitis is the name applied to an ulcerative inflammation of the cornea, which arises when this structure becomes anæsthetic, because it is severed from the influence of the trigeminus.

Cause.—The corneal lesion has been ascribed to a trophic change; to the lessened power of resistance which the cornea in its insensitive condition presents to external injuries; to the irritation of the fifth nerve by the lesion; to micro-organisms; and to increased evaporation from the surface of the cornea.

Disease of the Gasserian ganglion, disease of the nuclei of the fifth pair, periostitis of the orbit, syphilitic deposits, and fracture of the skull may cut off the trigeminal influence and cause the affection. Probably in most instances a combination of the trophic and traumatic theory best explains the disorder.; foreign substances remain undetected upon the insensitive cornea, whose resisting power is weakened through loss of trophic influence.

Symptoms.—The keratitis begins in the true corneal tissue, and rapidly spreads forward until the central necrosis or slough separates, and perforation of the cornea with prolapse of the iris occurs. The anterior chamber may contain pus, or pus mixed with blood. Beyond and around the central abscess, the corneal tissue is comparatively clear, but in the periphery there are secondary foci of infiltration, closely connected with inflammation of the neighboring conjunctiva. The surface of the cornea and conjunctiva is anæsthetic. The intraocular tension is diminished. There may be considerable pain and irritation, or these symptoms may be absent.

The *prognosis* is extremely unfavorable, and in spite of treatment destructive inflammation commonly results.

Treatment.—The affected eye should be excluded from the influence of external irritants, either by a carefully applied antiseptic bandage, or by stitching together the lids. Experimental evidence indicates the propriety of preventing evaporation by keeping the eye in a moist atmosphere.

Herpes Corneæ.[1]—The corneal lesions associated with herpes zoster ophthalmicus have been described on page 192. The present disease consists of a vesicular eruption upon the cornea, which breaks down and forms an ulcer, characterized by a denudation of epithelium not unlike that produced by injury.

Causes.—Horner has described herpes of the cornea with whooping-cough, intermittent and typhoid fever, and in general terms, with those affections in which herpes of the lips and nose are found. It is seen in acute and subacute disease of the posterior nares and pharynx, and also in affections of the respiratory apparatus generally (pneumonia—bronchitis).

Symptoms.—The disease begins with a series of transparent vesicles upon the cornea, which have been compared to a string of small beads. The vesicles are placed in a circle, or run in a diagonal line across the cornea. They speedily rupture and leave an open patch, deprived of epithelium, which is anæsthetic and has irregularly serrated margins, upon which the remains of vesicles may be seen.

The progress of repair is slow, and is often interrupted by the reappearance of fresh vesicles. The disease may be complicated with pus in the anterior chamber and iritis. Pain in the eye and brow, photophobia, lachrymation, and a gritty sensation are the subjective symptoms.

Treatment.—This consists in relieving the general condition; usually quinine in full doses is indicated. Locally, in the stage of irritation, atropine with cautious use of cocaine, warm compresses and dark glasses are needed. Calomel dusted into the eye is recommended. After the formation of the ulcer the treatment is conducted on general principles. Eserine now may be substituted with advantage, if there is no iritis, and in stubborn cases a light application of the actual cautery is useful.

Keratitis Bullosa in many instances is a symptom and not a separate disease, inasmuch as it consists of the formation of one or more small blebs of short duration (*K. Vesiculosa*), or of larger blebs of more enduring existence (*K. Bullosa*), upon the

[1] This term, as Horner observes, is often incorrectly used as synonymous with phlyctenular keratitis.

cornea of an eye, the subject of irido-cyclitis, interstitial keratitis, or glaucoma.

The *cause* of this affection, which formerly was attributed to a mechanical effect due to increased intraocular tension, is not entirely clear, but probably depends, according to Fuchs, upon an abnormality of the lymph circulation, in which a stasis takes place resulting in œdema of the cornea and a blister-like elevation of the corneal layers and the epithelium. Sometimes moderately large vesicles form upon a cornea otherwise normal, and in one reported case malaria was believed to be the chief factor in their causation.

The *symptoms*, in addition to the formation of the blebs, are burning pain, photophobia, injection of the bulbar conjunctiva, and rupture of the vesicles, leaving an abrasion which may go on to ulceration. There is a strong tendency to recurrence, and with each new formation of vesicles the violent inflammatory symptoms are repeated.

The *treatment* consists in puncture of the blebs, and suitable local measures, according to the causative disease. In bad cases iridectomy and even enucleation may be needed. The recurrent character and the remissions which have been described have suggested the use of antiperiodic doses of quinine; and these have been given with good results.[1]

The second group of corneal inflammations is the *non-ulcerative*, and includes a variety of affections usually unattended by the development of ulcers, but among which some are described that occasionally present the lesions seen with ulcers in the course of their development. Abscess of the cornea, if it remains with unbroken boundaries, is a suppurative but non-ulcerative affection and naturally belongs in this group. As in many instances its walls break down and an open ulcer results, it has been described with the ulcerated forms of corneal disease.

[1] Herpes of the cornea, the corneal complications of herpes zoster ophthalmicus (page 192) and the two varieties of the keratitis just described have been gathered by Fuchs under the general caption of *keratitis with vesicle formation*, to which category he adds that type of corneal disease known as *relapsing erosion of the cornea*.

Vascular Keratitis is a superficial vascularity and opacity of the cornea, and is seen in pannus caused by granular lids (page 243) and in phlyctenular pannus, the result of many relapses of phlyctenular keratitis (page 261).

Another form of vascular keratitis is characterized by the formation of two opposite vascular areas at the upper and lower margins of the cornea, which approach each other until the vascularization is complete. The disease is met with in young adults and in unhealthy, scrofulous and underfed children. The second eye usually is attacked, and, as has been pointed out by Carter, the character of the disorder indicates a perverted action of the nerves which govern the areas affected, and places it in analogy with herpes.

Symptoms.—These begin insidiously with slight intolerance of light, preceding the appearance at the upper margin of the cornea of a crescent of closely arranged bloodvessels, which, as they advance, push before them a border of corneal opacity. Simultaneously the same appearances become manifest at the lower margin. Clearing begins at the borders, and the whitish opacity which remains leaves the centre last of all. In the early stages the disease may be mistaken for conjunctivitis. All cases must be regarded with anxiety, and some do not clear up entirely. (Compare page 285.)

Treatment.—Local irritants are contraindicated. Atropine, cocaine, and warm fomentations in the early stages, and later a salve of the yellow oxide of mercury, or calomel, are useful. The best internal treatment is a prolonged course of iron and bichloride of mercury. Iridectomy for new pupil may be necessary, and the convex side of the vascular crescent may be touched with the galvano-cautery.

Interstitial Keratitis (*Syphilitic, Inherited, Specific, Parenchymatous, Strumous, and Diffuse Interstitial Keratitis*).—This is a diffuse keratitis in which a chronic inflammation of the whole thickness of the cornea takes place, until, usually without ulceration, but always with superficial or deep vascularization, the cornea passes into a condition of universal thick haziness.

Causes.—The majority of cases of interstitial keratitis are due to inherited syphilis; in rare instances it is caused by

acquired syphilis. In spite, however, of the not infrequent occurrence of this affection, the exact cause of its development is not always of ready demonstration. Evidence of inherited syphilis is present in between sixty and seventy per cent. of the cases, and it is probable that this percentage would rise higher, if the separation of typical cases was made from such as are only similar in appearance to the true disease.

In addition to the influence of hereditary syphilis this disease has been attributed to rachitis, scrofula, malaria, rheumatism, and depressed nutrition.

It is most frequently seen between the ages of five and fifteen, occasionally as early as three years, but rarely after thirty. A few cases are on record as late as the sixtieth year of life. Some statistics show that interstitial keratitis is more frequent in females than in males. The average age for males to be attacked is about seventeen, while women are affected a year and a half earlier, because a large number of cases occur about the supervention of menstruation. The greater immunity of the male sex from this disease does not, however, appear in all cases, other statistics showing an equal susceptibility, and still others a greater liability on the part of males.

Interstitial keratitis appears to have been aggravated by the development of menstruation, and also to have undergone improvement by establishment of the menstrual molimen. It is probable that the affection occasionally arises *in utero*, and a congenital form of interstitial keratitis, not differing in appearance from the ordinary or post-natal form of the disease, has been described. (Randolph.)

Symptoms.—After a few days of slight ciliary congestion and watering, a faint cloudiness appears, usually, but not always, near the centre of the cornea. The spots of haze, if carefully examined, will be found to be interstitial opacities, that is, within the structure of the cornea itself, and not on either surface.

In two or three weeks they spread until the whole cornea is invested with a diffuse haziness, veiling or completely hiding the iris except, perhaps, through a narrow rim at the margin of the cornea. The steamy surface has often been compared to ground glass. Careful inspection will reveal that the opacity is not uni-

form, but contains saturated whiter spots scattered through it, which have been described as "centres of the disease." There are always at this stage ciliary congestion, and some pain and dread of light. Bloodvessels derived from the ciliary vessels are thickly set in the layers of the cornea and produce a dull red color—"the salmon patch of Hutchinson." These patches may be small and crescent-shaped, or large and sector-like. In one type (referred to on page 283) the vascularity creeps from above and below until the entire cornea is cherry red.

The subjective symptoms of irritability and photophobia are more pronounced in strumous children who are at the same time syphilitic. Ulceration rarely occurs, but none the less ulcers of discoverable size are sometimes present, and hypopyon and an appearance resembling an accumulation of pus in the layers of the cornea have been reported. Iritis and the formation of posterior synechiæ are not uncommon, in one form the iritis being associated with deposits on the posterior layer of the cornea and the formation of anterior synechiæ. Inflammation of the ciliary region is occasionally encountered; secondary glaucoma and shrinking of the eyeball may follow.

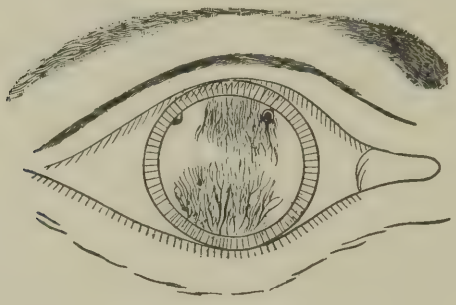
In the course of time, varying in accordance with the treatment, the eye begins to clear, usually from the periphery. Perfect recovery of the transparency must be rare, although the remaining haze may be slight. Years after an attack of interstitial keratitis minute vessels, nearly straight, branching at acute angles and short bends, may be detected in the cornea. These appearances have been especially described by Nettleship and Hirschberg, the latter observer stating that the vessel formation never subsides entirely, and he has seen this condition, with the aid of a corneal loup, thirteen years after an attack.

In addition to the complication of iritis and inflammation of the ciliary body, more or less retinitis is very apt to be present, sometimes not detected until after the clearing up of the cornea. Disseminated choroiditis, and even optic neuritis and retinal hemorrhage have also been reported. The presence of the vessels and the deposits in the retina and choroid after the disease has subsided may be utilized for the diagnosis of inherited syphilis.

The subjects of typical forms of this disease often present a

remarkable combination of physical defects. The dwarfed stature, the coarse flabby skin, the sunken nasal bridge, the scars at the angle of the mouth and also of the nose, the mal-formed perma-

Fig. 92.



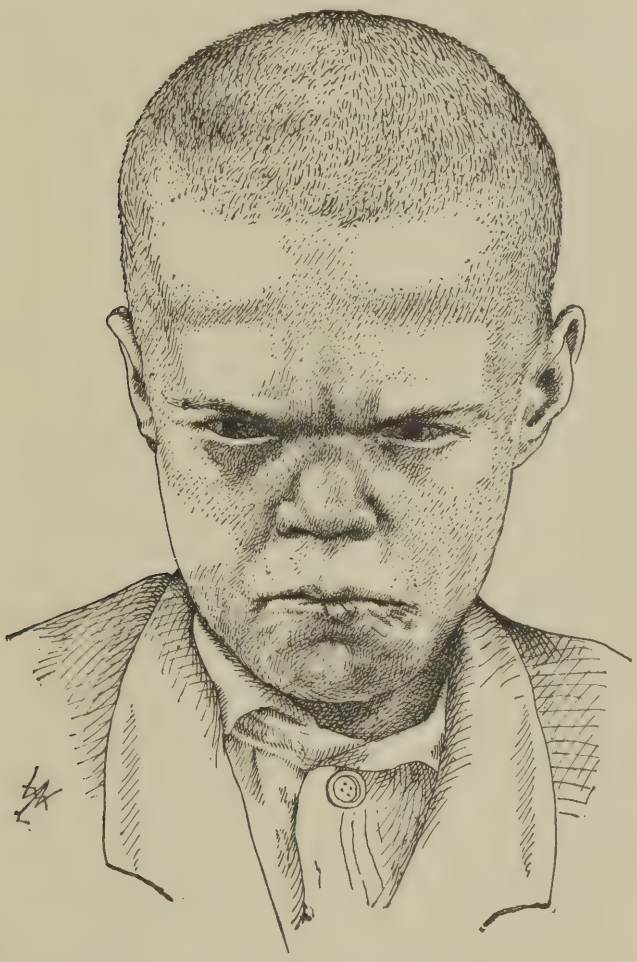
Vessel formation in the cornea after interstitial keratitis. (Hirschberg.)

nent teeth, in which the central incisors have vertically notched edges (Hutchinson's teeth)[1] indelibly stamp the inheritance of the patient. This character of teeth is present in between twenty and thirty per cent. of the cases. Indeed, it has been seen as frequently as thirty-one times in forty-eight cases. The presence of deafness, cicatrices in the pharynx, chronic periostitis of the tibia, and indurated post-cervical and epitrochlear lymphatic glands still further emphasize the syphilitic taint. (Fig. 93.)

[1] Dr. Harrison Allen, writing concerning "Hutchinson's teeth," says: "When the term 'Hutchinson's teeth' is used by clinical writers, a definite shape is at once presented to the mind. A disposition exists for the lateral incisor teeth of the upper jaw to become pegged, and for the central incisor teeth of the same jaw to be slightly convex at the sides and to be deeply emarginate (forming a crescent notch) on the free cutting surface. The molars of both the upper and lower jaw are often much swollen as their crowns lie in contact with the gum; the stunted cusps are seen rising abruptly and irregularly from the grinding surface. The prevalent views concerning the significance of such teeth are, in the first place, that they result from the poison of syphilis acting on the tissues before the birth of the child. Mimetic forms may take their origin during an attack of scarlet fever at a time when the teeth are not yet perfectly developed." This author describes cases in which it appears that Hutchinson's teeth, or allied deformation, may occur in a child in whom all the evidence of syphilitic taint or all lesions from scarlet fever are wanting.

DIAGNOSIS.—The course is usually quite typical and the associated symptoms characteristic. The tension of the eyeball and

FIG. 93.



From a photograph of a patient in the Children's Hospital, the subject of inherited syphilis and interstitial keratitis.

the age of the patient in most instances help to exclude primary glaucoma, while the history and character of the inflammation differentiate it from old corneal maculas and from the diffuse

infiltration of the cornea which is sometimes seen as the result of injury.

The presence of the minute straight vessels is good evidence of former interstitial keratitis. These vessels must be distinguished from those which remain after pannus from granular lids. According to Hirschberg, in the latter condition they are more superficial and pass into anterior conjunctival vessels. There are well-formed anastomoses, the broader veins are accompanied by finer arteries, and there are peculiar ramifications of the small deep vessels. The vessels seen in corneal scars after ulceration are confined to these cicatrices. The rest of the cornea is free.

Certain atypical cases of interstitial keratitis have been described, namely, forms in which the opacities are *stripe-like;* others in which they are *ring-like;* others presenting the appearance of pus in the layers of the cornea, the so-called *abscess forms;* others in which there is a combination of *interstitial keratitis* and *keratitis punctata*, and that form which is spoken of as *central annular interstitial keratitis*, especially described by Vossius, and usually seen in individuals under the age of twenty, and for which a definite cause has not been found. The variety which begins as a *marginal vascular keratitis* has been described.

Prognosis.—From six to eighteen months are usually consumed in the development of the various stages of the disease. The second eye is almost certain to be attacked in from a few weeks to two months. In rare instances, the interval is many months, even a year; it may be delayed from five to six years. The patient or his friends must be warned of this fact.

A return to perfect transparency is unusual. The vessel formation in the cornea probably never subsides entirely, but even long-continued opacity in the course of time may markedly lessen, and reasonable vision be restored. The occasional onset of deep-seated inflammation of the ciliary region, and the fact that after the cornea has cleared, evidences of former choroiditis, retinitis or disease of the optic disc, with glaucomatous cupping, may be discovered, must not be forgotten in rendering a prognosis.

Relapses are frequent, not only of the corneal disease, but of the complications found in the iris and retina. It has been

taught by some observers that the disorder is more severe now than in former times.

Treatment.—All irritating applications are harmful. Atropine to maintain mydriasis, prevent iritis, and allay inflammation, should be systematically employed. If the irritation is great, this drug may be cautiously combined with cocaine. Any high grade of inflammation calls for the frequent use of hot fomentations, and tenderness in the ciliary region will be relieved by a leech applied to the temple. The eyes may be protected from dust and light by goggles or a dark shade.

The best general medication is a long-continued course of mercury. Certainly in children, and probably in all instances, the most satisfactory method of administration in the earlier stages is by inunctions, one drachm of the ointment rubbed into the skin once or twice a day according to circumstances. It is a good plan to order the mercurial ointment to be put up in one drachm masses, thus securing the inunction of a definite quantity. The usual precautions in regard to changing the spots for the rubbings are to be observed. Whenever slight tenderness of the gums is apparent, the remedy should be discontinued, a chlorate-of-potash-mouth-wash should be ordered, and the patient put upon a course of iodide of potash.

During the administration of the inunction, cod-liver oil may be exhibited; later, bichloride of mercury is a valuable remedy, and, as many of the patients are anæmic, this is advantageously combined with the tincture of the chloride of iron. Suspicion of malaria calls for quinine and arsenic, and in any event they are useful adjuvants. If rheumatism or rachitis is present, the salicylates and phosphates are worthy of trial.

When all irritation has subsided, clearing of the remaining opacity is facilitated by the use of a salve of the yellow oxide of mercury, together with massage of the cornea, or by the local use of a solution of iodide of potash.[1] Iridectomy, if the tension rises and glaucoma threatens, may be necessary; it is evident

[1] Dr. James Wallace has found powdered aristol very useful in clearing corneal opacities the result of inherited syphilis. It should be dusted into the conjunctival cul-de-sac once a day.

that it should be employed for new pupil when stubborn central opacity remains.

A course of tonic treatment and due precaution in regard to nourishing diet, exercise, and healthful surroundings are advisable, in short, all measures are indicated which elevate the standard of the patient's general health. Some surgeons recommend that mercury be given in the form of hypodermic injections. An experience with this plan of treatment has not caused the author to abandon the older methods of administration.

Keratitis Punctata.—This affection is almost always secondary to disease of the iris, ciliary body, choroid or vitreous, and is characterized by a precipitate of opaque dots, generally arranged in a triangular manner, upon the posterior elastic lamina of the cornea (Descemet's membrane—hence also called *Descemetitis*). The overlying cornea is hazy, its surface at times slightly uneven.

The same name is also applied by some writers to those cases in which isolated whitish spots, surrounded by a cloudy area, appear in the parenchyma of the cornea. The disease is seen in young subjects, and is probably syphilitic in origin. Inflammatory evidences, the appearance of the white dots in the cornea, and later the development of iritis, with more diffuse corneal infiltration, characterize the disease.

Iodide of potash and bichloride of mercury are proper internal remedies. A continued atropine mydriasis should be maintained provided the tension does not rise; later iridectomy may be required to check the iritis, or for optical purposes.

Keratitis Profunda (*Central Parenchymatous Infiltration. Circumscribed Parenchymatous Keratitis*).—This form of keratitis is characterized by the formation of a grayish opacity in the deeper layers of the cornea, sometimes without severe irritative symptoms and unassociated with ulceration.

The *cause* in many instances is not discoverable; in others, cold, rheumatism, malaria, and injury apparently have originated the disorder.

The following is Fuchs's description of this disease: The gray opacity, usually in the centre, is covered by the superficial corneal layers which are hazy and stippled, but not absorbed. Close examination (with a loupe) of the corneal opacity resolves

this into individual points, spots, or gray interlacing stripes. The deposit slowly absorbs, without ulceration, and commonly with only slight vessel formation and leaves the cornea clear, or permanent opacity may remain. Symptoms of inflammation may or may not be present; there is hyperæmia of the iris. The duration of the disease is from one to two months.

The *treatment* requires atropine, dark glasses, and later, yellow-oxide or similar salve to aid resolution. The constitutional treatment is governed by the probable cause.

Among the more uncommon forms of corneal inflammation the following may be mentioned:—

Keratitis Superficialis Punctata (*Keratitis subepithelialis centralis, Keratitis maculosa, Noduli corneæ, Relapsing Herpes corneæ*).—This disease, which probably is akin to the herpes-like corneal inflammations, appears under several forms (just as it has been described under several names), either different types of the same disorder, or closely analogous manifestations.

Generally it begins with the symptoms of a sharp conjunctivitis in which the secretion is watery, while at the same time there is catarrhal disease of the respiratory tract. In two or three days numerous small punctiform or linear spots appear, not immediately beneath the epithelium, but below Bowman's membrane. The overlying cornea is slightly hazy and the epithelium above the spots a little elevated, the foci being more numerous near the centre of the cornea than at the periphery. The cornea intervening between the spots is somewhat hazy and contains small points and gray lines radiating hither and thither, comparable to the fine fissures in ice. The disease is tedious and may last for months. It occurs in young individuals and usually is bilateral.

Stellwag, whose description of the disorder differs somewhat from that of Fuchs, finds the foci most commonly in the periphery, and that the disease always begins with pain in the brow and circumorbital region. In his cases the duration was much shorter, cure having been effected in two weeks. Usually the disease is unaccompanied by loss of epithelium, ulcers, iritis, or hypopyon.

The anatomical nature of the spots is uncertain; probably they are enlarged and opaque corneal corpuscles, or lymph spaces filled with opaque matter. The cause of the disorder is unknown, except in so far as it is connected with catarrhal affections of the upper air passages. It is analogous to herpes, but differs from it in the absence of vesicle formation and herpes of the face, its bilateral character, and the great number of corneal spots or foci.

The *treatment* should be directed to the mucous membrane of the naso-pharynx. Locally, during the state of irritation, atropine is indicated and later yellow-oxide salve. Full doses of quinine would seem to be called for, and it has been recommended to use the constant current along the region of the distribution of the supraorbital nerve.

Keratitis Marginalis.—Under this name (which is here used in a sense quite different from that employed on page 260), Fuchs has described a rare form of keratitis in which a yellowish-gray zone of opacity, immediately joining the sclera, pushes into the clear cornea accompanied by severe inflammatory symptoms, and occupies about one-half of the corneal circumference. The vessels of the limbus cover the opacity; in several weeks these and the inflammatory symptoms subside, leaving a rim of infiltration somewhat like an *arcus senilis*, save only that it joins the sclera directly and is not separated from it by a stripe of clear cornea. The disorder is unaccompanied by ulceration.

It resembles the angular corneal opacity which appears in connection with scleritis, and which is known as *sclerotizing keratitis* (see page 303), but differs from it in the absence of any preceding scleritis. The disorder occurs in elderly subjects.

Riband-like Keratitis (*Primary Opacity of the Cornea, Transverse Calcareous Film of the Cornea, Keratitis trophica*) appears, as pointed out by Nettleship, in two forms.

In the one, usually in elderly people, the exposed part of the cornea is invaded in a transverse direction by a *smooth subepithelial* opacity, oval in shape, which can be chipped off, and is composed of an incrustation of lime salts. There is no ulceration, and no change in the overlying epithelium. The opacity

is sharply limited, and the remainder of the cornea is clear. The disorder almost invariably is symmetrical, occurs in men, and is situated upon the exposed cornea. A margin of the cornea at each end is free. Gout and excess of uric acid in the blood have been suggested as constitutional causes, a suggestion strengthened by the occasional occurrence of insidious iritis, glaucoma, and hemorrhagic retinitis. It may be mistaken for the opacity which occurs from the injudicious use of salts of lead.

In the other type of the affection, a horizontal band of opacity, grayish-brown in color, crosses the corneæ of eyes which have long been blind from irido-cyclitis, sympathetic ophthalmia, and glaucoma. Here the stripe is less uniform, less sharply defined, and consists of a *roughened* transverse opacity. The calcareous nature of the other type may be wanting. As it occurs in the lower third of the cornea, or that part exposed when the eye is rolled up, and in an eye with impaired nutrition, the affection has been considered trophic in its nature.

Arcus Senilis (*Gerontoxon*), or a circle of fatty degeneration just within the margin of the cornea, is, as its name implies, almost invariably found in old persons. A true arcus is always separated from the adjacent sclera by a thin stripe of clear cornea. Occasionally a genuine example of this affection appears to have been noted in children (Hansell). Instances which have been reported at birth must not be confounded with an arciform opacity, the result of ulceration.

The affection requires no treatment, and its presence appears not to interfere with the healing of wounds; for example, in cataract incision.

Conical Cornea (*Keratoconus*).—This consists of a cone-shaped bulging forward of the cornea, and is rarely congenital. It is mostly seen in women, and usually does not develop until after the age of fifteen. Exhausting illness, menstrual disturbance, and especially chronic dyspepsia, have been observed to be associated with the development of conical cornea, the immediate cause being a disturbance in the relation of the intraocular pressure to the resistance of the cornea.

The cone is transparent in most instances; occasionally its apex is slightly opaque. The bulging slowly progresses, but does not rupture nor ulcerate. After years it comes to a standstill. One or both eyes may be involved, commonly the latter, the second eye being affected some time after its fellow. The eye becomes myopic and highly astigmatic. Slight forms of conical cornea may be overlooked, unless the shadow-test is employed and the characteristic reflections observed.

Fig. 94.



Conical Cornea. (Swanzy.)

Treatment.—Although no form of glass, or no optical apparatus may avail in advanced cases, a careful trial should always be made with sphero-cylindrical combinations, and in some instances their employment in unusual combinations will markedly improve visual acuity. It is always wise to use eserine (gr. $\frac{1}{8}$–f℥j) for several weeks before attempting the correction (Wallace).

If the apex of the cone appears to be thinning, a weak solution of sulphate of eserine and a compressing bandage are indicated.

In advanced cases an operation is advised, having for its object the substitution of a contracting cicatrix for the tissue at the apex of the cone, which shall diminish the excessive curvature. Several plans are suggested: (*a*) Cutting off a small, superficial flap and subsequently cauterizing the surface, associated with repeated paracentesis of the cornea, and later a small iridectomy for optical purposes; (*b*) cutting off the flap and drawing the edges of the wound together with delicate sutures; (*c*) cutting from the apex of the cone a small disc, with a trephine; (*d*) multiple punctures with fine needles; (*e*) obtaining the desired loss of substance by the application of a galvano-cautery. As the resulting scar is directly central, an iridectomy for optical purposes will usually be required, an operation indicated under any circumstances if the tension rises.

Buphthalmos (*Hydrophthalmos congenitus, Kerato-globus, Megalocornea, Glaucoma congenitum*).—In this affection there is slow but progressive enlargement of the eye in all its diameters;

the cornea is flatttened, the sclera thinned, and the anterior chamber deepened; the tension is raised. In the course of time the cornea may become cloudy (*kerato-globus turbidus*), although this is not always the case (*kerato-globus pellucidus.*)

The affection appears at birth or shortly afterwards, and its incipient stages are believed to be intra-uterine. The precise cause is not accurately determined. It has been ascribed to an intra-uterine irido-keratitis with increased intraocular tension; in other words, a form of congenital glaucoma.

The *prognosis* is unfavorable; the affection usually progresses to blindness. Iridectomy has been practised with poor success; some favorable results with sclerotomy have been reported. Eserine or pilocarpine should be tried.

Injuries of the Cornea. Traumatic Keratitis.—These comprise (1) foreign bodies; (2) erosions; (3) wounds; and (4) burns and scalds.

Foreign bodies like particles of sand, fine splinters of iron and bits of emery, may lodge either upon the epithelium or become imbedded in the substance of the cornea. If they are sharp, like a splinter of iron, or small thorn from a chestnut-burr, they may partially penetrate the membrane.

The pain of even a minute foreign body is considerable; the eye waters and grows red, and the source of irritation is commonly referred to the under surface of the upper lid, although the intruder may be directly upon the centre of the cornea.

To remove an imbedded foreign body a drop of a four per cent. solution of cocaine is instilled, the upper and lower lids are held apart with the thumb and forefinger of the surgeon's hand, while with the right hand he takes a fine needle, or a spud, and lifts the body from its position with as little injury as possible to the cornea. Sometimes, if the situation is deep, several digging motions with the instrument will be required to dislodge the substance. The area should afterwards be inspected by means of a two-inch lens and oblique illumination. In any case in which the operator is not sure that he has removed the foreign substance he may resort to the fluorescin-method described on page 62. If the substance has been iron or emery, a small,

rust-like spot will often be seen even after the body itself has been removed.

If the spicule has partially penetrated, it may be necessary to pass a broad needle through the cornea behind it to secure a surface against which to work, and to prevent the manipulations from pushing it entirely through the cornea and into the anterior chamber.

After the removal of the foreign body, the resulting irritation may be allayed by a drop of atropine; the use of a bandage for a few days will facilitate the healing of the ulcer. Disinfection of the conjunctival cul-de-sac with a bichloride lotion, and sterilization of the spud should be secured.

Erosions.—A superficial loss of epithelium caused by the contact of a sharp body, like a finger nail, in itself may be insignificant, but may lead through septic infection to a severe ulceration, particularly if the injured eye is exposed to the discharge from an inflamed lachrymo-nasal duct.

The *treatment* consists of the instillation of an antiseptic lotion, like bichloride of mercury (1-8000) and the use of atropine, with a compressing bandage to immobilize the lids until healing takes place, provided no septic discharge is present.

A number of cases, in which violent neuralgic pain has followed an insignificant scratch of the cornea, have been reported; this condition is called *traumatic keratalgia.* The attacks of pain recur again and again and may last for years. The affection probably is due to a neuritis of a corneal nerve filament.

The remarkable affection, *relapsing erosions*, has been referred to, and belongs to the types of corneal disease associated with the formation of vesicles.

Wounds of the cornea naturally divide themselves into *non-penetrating* and *penetrating*, and differ in character according to the implement which has inflicted them.

Non-penetrating wounds partake of the nature of erosions, and, like them, may be in themselves of minor importance, but may result in violent ulcers through microbic infection.

The treatment already described is applicable.

A *penetrating* wound allows the escape of the aqueous and renders incarceration of the iris liable, with all the possibilities

described in connection with perforating ulcers. The wound may injure the lens and cause traumatic cataract, or involve the ciliary region and lead to sympathetic inflammation in the fellow eye.

After a perforating wound of the cornea, the eye should be thoroughly disinfected, the iris, if prolapsed, replaced if possible, and eserine or atropine instilled according to the situation of the injury. If replacement is not possible, the prolapsed portion should be seized with iris forceps and excised, after the manner of performing an iridectomy. In either event the subsequent treatment requires rest, disinfection of the conjunctival cul-de-sac, and a carefully applied antiseptic compressing bandage.

The tendency to traumatic iritis may be combated by the frequent use of cold compresses. Inflammatory reaction would call for a leech to the temple. In severe corneal wounds, involving the iris, lens, and ciliary body, the question of enucleation or evisceration must be decided.

Burns and Scalds are produced by the contact of acids, lime, molten metal, and hot water or steam, and the general management of such cases does not differ from that of similar accidents to the conjunctiva which necessarily is involved.

Sometimes the burn may be superficial and the whole surface-epithelium be changed into a white scum, which presents a most alarming appearance. The destroyed tissue, however, is speedily replaced by a new layer of epithelium. Burns with slaking lime are those most liable to result in disastrous consequences.

All the various forms of corneal injury cause more or less severe inflammations properly classed under the general term *traumatic keratitis*, and possess in greater or less degree the cardinal symptoms of keratitis—pain, lachrymation, photophobia, and disturbance of vision.

Tumors of the Cornea.—These are very rare and include the growths which develop from the epithelium—*epithelioma*, or invade it by extension from the neighboring tissues—*sarcoma*. A few instances of *fibroma* and *papilloma* have been reported.

Dermoid tumor is a congenital growth, and sometimes is associated with other anomalies of the lid and eyes. It occurs as a firm hemispherical, yellowish-white growth, lying partly upon

the cornea and partly upon the conjunctiva. The apex, often paler than the rest of the growth, is covered with short hairs. These, however, occasionally grow to an unusual length and have been seen protruding through the fissure of the lids and hanging down upon the cheeks. If undisturbed, the tumor may slowly enlarge, and has been reported to have attained the size of a walnut. Bilateral dermoids have been recorded.

These dermoids have been ascribed to the remains of amniotic adhesions; but also to the coalescence of the lids in such a way that at the moment of separation one lid attracts to itself a portion of the other. Microscopically, the growth represents the structure of the skin and its appendages. The presence of striped muscle fibre and acinous glands, analogous to those in the conjunctiva, has been described in dermoid tumors growing from the caruncle.

Fig. 95.



Dermoid of the cornea. From a patient in the Philadelphia Hospital.

Congenital Anomalies of the Cornea.—*Microphthalmos* is that condition in which the entire eye remains in a more or less rudimentary state, and in which the cornea is too small in all its diameters. Pure cases of microphthalmos, according to Manz, are very rare; usually one or other of the component portions of the globe is wanting. Numerous theories have been expressed in regard to the etiology,—retarded growth of the cerebellum (Kundrat), incomplete closure of the fœtal ocular cleft (Arlt), fœtal illness *in orbita* (Wedl and Boch), intrauterine sclero-choroi-retinitis (Deutschmann). The affection has also been ascribed to the influence of heredity.

Megalophthalmos has been described on page 294.

Sclerophthalmia is that condition in which the opacity of the sclerotic encroaches upon the cornea in such a manner that only the central portion remains transparent. It is due to an imperfect differentiation of the cornea and sclera at an early period of fœtal life.

Congenital opacities of the cornea are seen in the form of milky spots which may clear up in later life, or as dense leucomas. They are due either to intra-uterine inflammation, or to an arrest of development.

Congenital staphyloma of the cornea appears in the form of a true staphyloma, and is a rare affection. The abnormality depends not so much upon a malformation, or an arrest of development, as upon a fœtal inflammation which, according to Pincus, takes place in the second half of fœtal life. Heredity probably plays some rôle in this and similar affections of the cornea. Congenital staphyloma of the cornea associated with dermoid formation has been reported.

CHAPTER VIII.

DISEASES OF THE SCLERA.

The sclera, constituting four-fifths of the covering of the globe of the eye, and being in intimate relationship by its under surface with the choroid and ciliary body, is subject to inflammations peculiar to itself, and to changes indicative of disease of these subjacent structures. Its close connection with the cornea associates the latter membrane in some phases of its diseases, and its union with the iris through the pectinate ligament establishes an anatomical connection, just as there often is a pathological relation. The overlying bulbar conjunctiva necessarily participates in scleral inflammation.

The inflammations affect (1) the episcleral tissue (*episcleritis*); and (2) the sclera itself (*scleritis*), and hence are *superficial* or *deep*. They further are *acute* or *chronic*, *diffuse* or *circumscribed*.

Episcleritis occurs in the form of small, dusky red, sub-conjunctival swellings, which usually appear in the ciliary region on the temporal side of the cornea, though patches may occur in any portion of the zone.

The conjunctival vessels over the patch are coarsely injected, and movable with the somewhat œdematous conjunctiva. The episcleral vessels show a dusky congestion which is immovable. The elevation is back-shaped; sometimes tender to pressure and sometimes not, and there may or may not be much irritation and pain. In some cases of thickened phlyctenular disease of the corneal margin it is difficult to decide between this affection and episcleritis; what appears to be a patch of the latter may develop into the former.

The disease runs a subacute course, reaching its height in about three weeks, then gradually disappears and leaves a somewhat dull area of discoloration, marking its former position. Relapses are frequent, both at the original seat, or in new spots on the sclera,

and these recurrences may happen again and again for months and even years.

Cause.—It is said to be more common in men than in women. (Nettleship.) Patches of episcleritis of the character described occur in the eyes of those who are much exposed to the weather. In other cases superficial scleritis is caused by rheumatism, scrofula, menstrual derangements, and also appears without cause. It is probable that a patch of episcleral congestion may be maintained by insufficiency of the ocular muscle inserted in the neighborhood of its location.

In this form of superficial scleritis the *prognosis* is good so far as sight is concerned, because deeper and adjacent structures are uninvolved, but unfavorable on account of the recurrences.

Treatment.—This consists in the use of atropine to allay pain and prevent any tendency to iritis, warm antiseptic collyria, and hot compresses. In the chronic types eserine and pilocarpine have a beneficial influence, provided no iritis is present. Eserine may be employed in the strength of $\frac{1}{4}$–$\frac{1}{2}$ of a grain to the ounce; several drops three times a day,—stronger solutions give rise to pain. Massage with a salve of the yellow oxide of mercury is very useful in chronic cases, and it has been recommended to scarify the tumefaction, scrape it away with a sharp curette, or cauterize it with the actual cautery. Internally, salicylic acid and iodide of potash are needed in rheumatic cases, and good results follow diaphoresis either with jaborandi or the Turkish bath. Any error of refraction or anomaly of the external eye muscles should be corrected.

Scleritis may appear in the form of a *diffuse* bluish-red injection, occupying the entire exposed portion of the sclera, very painful, unattended with secretion, save some increase in lachrymation, and liable to be mistaken for conjunctivitis or iritis; or in the form of *circumscribed* patches, of violaceous tint, situated in the ciliary region and somewhat resembling in appearance the forms of superficial or episcleral elevations just described, being, however, less sharply defined, so that the whole zone may be involved, but in unequal degree. The chief distinction between the *superficial* and *deep* forms of scleral inflammation is the almost

invariable tendency of the latter to affect other portions of the eye.

Cause.—The *causes* of deep scleritis are exposure to cold, rheumatism, gout, scrofula, vaso-motor changes, and disturbances of the sexual apparatus, especially anomalies of menstruation. Syphilis may form the so-called *gummatous scleritis*, in which the patches are yellowish-brown and translucent; and gonorrhœa, when this is associated with synovitis, may also cause the disorder. Finally, types of scleritis (sclero-keratitis) unassociated with any definite cause or diathesis, are seen in young and middle-aged subjects, most commonly women, whose nutrition is depressed, and who may or may not have a scrofulous disposition or inheritance.

Deep scleritis usually attacks both eyes, runs a chronic course, and may affect the iris (leading to closure of the pupil), ciliary body, choroid, vitreous (causing opacities), and the cornea. In prolonged cases of the disease dark scars remain after absorption of the products of the inflammation, which are unable to resist the intraocular pressure, and form elevations (ectasia scleræ). Sometimes the whole anterior portion of the sclera becomes bluish or slaty-colored, is misshapen and elongated, and the cornea, which appears small, is poorly differentiated from it on account of the haziness of its margins.

Sclero-kerato-iritis (*Scrofulous Scleritis, Anterior Choroiditis*). —This name is applied to the complicated scleritis referred to in the previous paragraph, and is characterized by chronicity, relapses, and involvement of the cornea and iris.

Beginning with a deep scleritis of the ciliary zone, the adjacent cornea becomes opaque, and sometimes ulcerates; the iris is inflamed, posterior synechiæ form, and pain and congestion may be severe. After weeks the symptoms subside, the characteristic discolored area marks the former scleral disease, and haziness in the cornea indicates the seat of previous inflammation in this membrane. Then relapse takes place, with fresh scleritis, new corneal involvement, renewed iritis, or irido-choroiditis, and vitreous changes, and so on, until after many months, it may be, the disease comes to an end, leaving the sclera discolored and bulged, the cornea covered with patchlike opacities, the iris bound down

with adhesions, the vitreous filled with opacities, and the eye practically deprived of vision.

Sclerotising keratitis, referred to on page 292, is the name applied to a patch of opacity in the deeper corneal layers, usually triangular in shape, with its base towards the patch of scleritis which is its origin. After the cure of the scleritis, a white or yellowish-white opacity remains directly in contact with the sclera by its margin. Instead of a single patch of this character, several small triangular areas may arise in the circumference of the cornea as the result of scleritis.

Treatment.—The treatment of scleritis and sclero-keratoiritis depends upon the type and stage of the disease, and the presence or absence of definite cause. It resembles that already described with episcleritis. Locally, atropine, hot compresses, cocaine and boracic acid lotion, and in painful cases leeches to the temple, are suitable. The eyes should be carefully protected with goggles. After the subsidence of acute symptoms, massage may be tried. The use of the actual cautery has been mentioned.

In rheumatic cases, salol, the salicylates, the alkalies and iodide of potash are the most available remedies; in gout, carefully regulated diet, mineral waters—Buffalo, Poland, etc.—citrate of lithium, colchicum, especially in the form of colchicin, and change of climate are useful. In scrofulous cases, cod-liver oil, iodine, iron, and sweats with pilocarpine (gr. $\frac{1}{10}$ hypodermically), or 15–30 minims of the fluid extract of jaborandi, are indicated. The diaphoretic measures are proper in any case, other things being equal. In syphilis, bichloride of mercury, and, if the nutrition permits, inunctions of mercurial ointment, are efficacious. Indeed, mercury is generally advantageous as a means of altering the nutrition of the part and preventing exudation into the uveal tract. Disorders of menstruation should always be corrected. Finally, in subjects with depressed nutrition, quinine, arsenic, and a general tonic regimen are required.

It is not always possible to distinguish between episcleritis and scleritis, unless the latter term be applied solely to those cases which involve structures other than the sclera itself; neither is it always possible in the early stages to say whether or not a

patch of episcleral inflammation will develop into a serious type of the malady, or be temporary and abortive.

Staphyloma of the Sclera has been divided by systematic writers into *anterior*, *equatorial*, and *posterior* staphyloma, according to the situation of the lesion. The last is not visible to the naked eye, but, by the findings of the ophthalmoscope, may be inferred to exist in a highly myopic eye (see page 354).

It is evident that all bulging of the scleral depends upon a disturbance between the resistance of the sclera and the intraocular tension, but it is not evident in all cases whether the process which originated the trouble began in the underlying tissue or in the scleral structure itself. There may be a general enlargement of the scleral coat, as is seen in buphthalmos (page 294); or one or more darkly tinted swellings in the ciliary region may arise, one sometimes occurring in advance of each rectus tendon; or, finally, the staphylomatous swelling may exist at the equator in the region of the vena vorticosa.

The following *causes* may originate scleral staphyloma: Chronic glaucoma, old kerato-iritis and closure of the pupil, inflammation of the ciliary body, thinning of the scleral coat by repeated attacks of inflammation, tumors, and wounds closed by non-resisting scars.

Treatment.—A single scleral staphyloma may not destroy vision. If the intraocular tension is increased, an iridectomy is indicated. If the eye is useless, enucleation may be necessary.

Abscess and Ulcers of the Sclera are exceedingly uncommon, as the products of scleral inflammation rarely go on to suppuration or ulceration. Abscess in the scleral tissue may result from an infected wound, and has been seen in connection with certain specific and contagious diseases, *e. g.*, glanders.

Ulcer of the episcleral tissue has been described with scrofula. A tumor, gumma, or tubercle of another region of the eye may break down and ulcerate into the sclera.

Tumors of the Sclera are rare growths. The following have been seen: Fibroma, sarcoma, enchondroma, and osteoma.

The tissue of the sclera may be involved in a growth having its origin in a neighboring structure, *e. g.*, melano-sarcoma of the ciliary body. It is possible to dissect small primary scleral

growths from their beds and close the wound with conjunctival sutures.

Injuries of the Sclera.—Wounds of the sclera may be inflicted with a sharp implement (knife, scissors, broken glass, etc.), or foreign body (chip of iron or steel, bullet, etc.), or they may result from a blow (*rupture of the sclera*).

If the wound has *perforated* the sclera, two dangers at once present themselves: loss of a portion of the contents of the globe with injury to the inner coats, and the introduction into the eye of septic material which will cause destructive inflammation.

Symptoms.—A perforating wound of the sclera, if sufficiently large, causes loss in the tension of the globe, hemorrhage into the vitreous, or, it may be, into the anterior chamber, and the appearance of dark tissue in the wound, representing, according to its situation, portions of the choroid, ciliary body or iris, between which a bead of vitreous is likely to present. The diminution of intraocular tension may lead to the discovery of a small perforating scleral wound where the rent is obscured by the overlying contused and swollen conjunctiva. Rupture of the sclera is commonly associated with grave lesions in other portions of the eye—separation of the retina, and extensive tears in the choroid and iris.

Prognosis.—This depends upon (a) the extent and situation of the wound and amount of escape of vitreous; (b) the presence or absence of septic material upon the implement which inflicted the injury; and (c) whether a foreign body has remained within the globe. From this it is evident that even a trifling perforating wound, unattended with loss of vitreous or prolapse of the inner coats, may be a point of entrance of microbic infection.

Treatment.—Having determined, from the character of the implement, that no foreign body is within the globe, the eye should be carefully disinfected with a solution of bichloride of mercury (1-5000), and the edges of the wound pencilled with a stronger solution of the same drug (1-2000). The overlying conjunctiva is then drawn together with several fine sutures, or, if the wound is small, these may be omitted. The eye is closed with an antiseptic compressing bandage, and the patient is put to bed. At the end of forty-eight hours, the wound may be inspected

and the dressings renewed. In larger wounds it is better to pass the sutures directly through the sclera and thus draw the separated edges together; usually the sutures may be removed at the end of a week, if the healing has progressed favorably. Some surgeons advise the introduction of iodoform before the application of the bandage. The sutures may be of sublimated silk or fine chromacized catgut. In some instances, in spite of kind healing of the scleral wound, there is subsequent detachment of the retina, vitreous change and shrinking of the eyeball; but apparently hopeless cases may be saved by careful antiseptic surgery.

If the wounding substance has been small, like a chip of steel, a splinter of glass, or a bullet, endeavor should be made to ascertain whether this has penetrated the globe and remained within it, or has passed entirely through the eyeball and buried itself in the tissues of the orbit.

Unfortunately, the bleeding into the vitreous, or anterior chamber, is apt to obscure the media to such a degree that ophthalmoscopic examination is not of much service; if the media are clear, this may be the means of detecting the foreign body. Usually an attempt at locating this must be made by observing the situation of the wound, the probable direction which the body took on making its entrance, and by a search for points of tenderness, and a scotoma in the field of vision.

Having satisfied himself of the presence of a foreign body within the globe, the surgeon may attempt to extract it through the original wound with delicate, carefully disinfected forceps, or through a new wound made in the most favorable situation.

If the foreign body is known to be of iron or steel, an attempt should be made to dislodge it with an electro-magnet introduced through the entrance wound, or, if the case is not a recent one, through a wound made for the purpose.

In the event of a scleral wound being extensive, with much loss of vitreous and collapse of the coats, especially if the ciliary body is involved and sight practically gone, or if the endeavors to remove the foreign body have been unsuccessful, enucleation should be performed to avoid the dangers of sympathetic inflammation in the fellow eye.

Congenital Pigmentation of the Sclera (*Melanosis sclerœ*) occurs both in spots and as a more diffuse discoloration. The spots are more common in the upper portion, and may be associated with pigment changes in the iris and choroid. Pigment spots in the sclera have been observed in certain diseases, *e. g.*, Addison's Disease.

CHAPTER IX.

DISEASES OF THE IRIS.

Congenital Anomalies.—*Heterophthalmos*, or the condition in which the color of one iris is different from that of the other, is a peculiarity in most instances without pathological significance. It has been referred to on page 63.

Corectopia, a term applied to an eccentric position of the pupil, is not to be confounded with cases of true coloboma of the iris, presently to be described. The grade of corectopia may vary from a slight increase of the normal eccentric position of the pupil below and to the inner side, to those cases in which the whole pupil is displaced toward the border of the cornea. The latter variety is a very unusual phenomenon. This complete shifting of the normal position of the pupil has been ascribed either to an essential mal-formation, or to the result of a fœtal iritis. Both eyes may be affected symmetrically, and several members of the same family may present the defect.

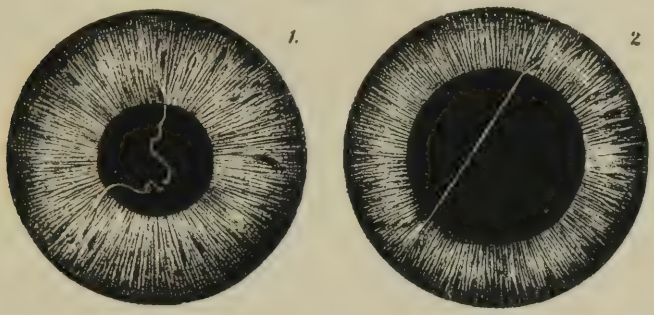
Polycoria, or a multiplicity of pupils, is a rare anomaly. The abnormal pupil or pupils may be situated in the immediate neighborhood of the normal pupil, separated from one another by a narrow band of iris-tissue, or the increased number of pupils may be the result of crossing strands of persisting pupillary membrane. An opening which exists at the ciliary margin of the iris has been described, and is probably due to a *congenital iridodialysis.*

Persistent pupillary membrane results from an incomplete resolution of the membrane which covers the anterior surface of the lens during fœtal life, and which usually disappears in the seventh month, although it may remain as late as the end of intrauterine life, and even in the first month after birth.

Accurately speaking, it is more proper to regard the pupillary membrane as a specialized portion of the *capsulo-pupillary*

covering. Those cases to which the name of pupillary membrane alone is applicable, are where threads attached to the iris pass diametrically or cord-wise across the pupil. (Fig. 96.) Several varieties of persistent pupillary or capsulo-pupillary membrane exist. Usually the fibres proceed from the anterior

Fig. 96.



Persisting pupillary membrane. 1. Pupil contracted. 2. Pupil dilated. (Wickerkiewicz).

surface of the iris across the pupil, either singly, or in groups of a dozen or more strands. Sometimes the fibres remain separated; sometimes they grow together in front of the anterior capsule; and sometimes they unite in the form of a variously colored plaque, adherent to the capsule of the lens. Persistent pupillary membrane is more common in one than in both eyes.

Capsulo-pupillary tags are not infrequently mistaken for the synechiæ due to iritis; indeed, the association of the two has been observed. No difficulty, however, should arise, because the normal action of the pupil is not impeded by the presence of these vestigial anomalies. The appearance is not often detected until some other disorder calls for an ophthalmoscopic examination, because vision is not seriously, or at all, impaired. Oblique illumination will readily demonstrate the remains of pupillary membrane, and, indeed, is the best method with which to study this phenomenon.

Coloboma of the iris is a fissure of this membrane which in a general way resembles an artificial pupil made by iridectomy. The anomaly is more frequent in both eyes than in a single eye. When the defect is unilateral, the anomaly is usually found on the

left side. The situation of the fissure is almost invariably downward, or downward and inward.

The coloboma may extend across the whole iris (*complete coloboma*), or stop at a certain distance from the ciliary margin (*incomplete coloboma*). In addition, the so-called *pseudo-coloboma* is described, which may be looked upon as a form of heterochromia of the iris, or indicates the last remains of the ocular fissure which is tending towards closure, and which appears as a small stripe, somewhat granular, and differentiated from the rest of the iris by its brighter color. In "bridge coloboma," the borders of the cleft are united by a narrow pigmented or colorless band of fibres.

Coloboma of the iris is frequently associated with similar defects in the choroid, and also with microphthalmos, congenital cataract, fissure of the eyelids, lips, and palate. Its probable cause is an arrest of development, the result of incomplete closure of the choroidal fissure. Much evidence has been brought to show hereditary tendency in this defect.

Irideremia, or congenital absence of the iris, occurs both in a *partial* and *complete* form. The appearance somewhat resembles an eye with complete mydriasis.

Total congenital irideremia is almost invariably bilateral. It is frequently associated with other anomalies of the globe—partial or complete cataract, dislocation of the lens, nystagmus, strabismus, departures from the normal curvature of the cornea, or annular opacities in its periphery. In a majority of instances there is a marked hereditary tendency.

Congenital ectropion of the uvea consists in a round mass of dark color projecting from the margin of the pupil, bending around to the anterior border of the iris. A similar formation is proper to the eye of the horse and is frequently seen in the cow. This appearance has sometimes been described as a papilloma of the iris; it is not, however, a neoplasm, but a congenital ectropion of the uvea.

Cysts, nævi, and atrophies of the iris occur as congenital defects.

Functional Motor Disorders of the Iris.—Under this heading may be mentioned *mydriasis*, or dilatation of the pupil; *myosis*, or contraction of the pupil; *hippus*, or alternate contraction and

dilatation of the pupil; and *irido-donesis*, or tremulous iris or an oscillation of the iris depending upon want of support, as, for instance, in dislocation of the lens.

The chief causes of mydriasis, myosis, and hippus have been described in the section devoted to the pupil, on page 64.

Hyperæmia of the Iris is associated with several acute affections of the eye, for example, acute trachoma, purulent ophthalmia, keratitis, scleritis, inflammations of the uveal tract and traumata, and is a precursor of inflammation. Hence it is a symptom rather than a special disease of the iris itself.

Hyperæmia of the iris is recognized by change in color, a blue iris becoming greenish, a brown iris, reddish-brown; by contraction of the pupil, which dilates sluggishly, or not at all, to the changes of shade and light, and is slowly affected by a mydriatic, the effects of which are much less permanent than in the healthy iris; and by slight pericorneal injection.

The *treatment* consists in the management of the disease which has caused the hyperæmia, and especially in the instillation of atropine.

Iritis.—Under the general term *iritis* are included various types of inflammation of the iris which may be (*a*) idiopathic; (*b*) symptomatic of disorders in other portions of the eye, or of disease in the general constitution; and (*c*) traumatic.

Symptoms.—(1) *Change in the color* of the iris, in addition to loss of its natural lustre and obscuration of the characteristic striated appearance.

(2) *Pericorneal injection*, due to congestion of the non-perforating branches of the ciliary vessels (System II.), producing the fine pink zone surrounding the cornea known as "ciliary congestion," or the "circumcorneal zone." In severe cases, there may be distension of the posterior conjunctival vessels, and slight chemosis of the conjunctiva.

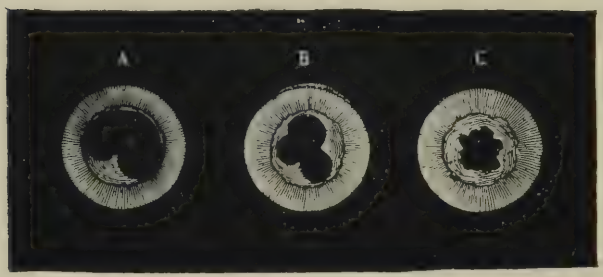
(3) *Myosis*, or contraction of the pupil, due partly to hyperæmia, and partly to irritation of the peripheral nerve filaments. The reaction of the pupil to the influence of light and mydriatics is diminished or lost.

(4) *The formation of posterior synechiæ*, or inflammatory attachments between the iris and the capsule of the lens. These

may be suspected when the pupil fails to change its diameter under the varying influence of light and shade, and are demonstrable by the instillation of a mydriatic, which will produce an irregular dilatation of the pupil, certain portions of the pupillary margin of the iris being held back by somewhat tongue-shaped projections attached to the lens capsule.

The attachments may vary in size, firmness, and number; being either narrow and thread-like, broad and dense, single or multiple, or even extending all around and pinning down the margin of the iris in an annular manner. In association with the synechiæ there may be an exudate of false membrane covering the whole pupillary space.

Fig. 97.



Various forms of posterior synechiæ. *A.* Single attachment. *B.* Multiple attachment forming the so-called "ace-of-clubs" pupil. *C.* Irregular annular attachments (Sichel).

(5) *Irregularities in the surface of the iris*, due to local swellings, accumulations of exudate, or the formation of nodules.

(6) *Haziness of the cornea*, or in certain types, deposits upon its posterior surface.

(7) *Change in the character of the aqueous humor;* (*a*) slight or considerable turbidity; (*b*) pus; (*c*) blood; and (*d*) occasionally exudate.

In addition to the symptoms just detailed there are *subjective* signs more or less peculiar to iritis.

(1) *Pain.*—This is situated first in the eyeball and is known as "ciliary pain," and second in the brow and temple, sometimes

quite sharply defined in the distribution of the supraorbital nerve, very severe, throbbing and stabbing in character, and with marked increase in severity during the night. Occasionally the nasal and infraorbital regions are the painful areas.

(2) *Disturbance of Vision.*—This is in direct proportion to the amount of cloudiness which has occurred in the media. Very great impairment of visual acuity denotes extension of the disease to the ciliary body or deeper structures. During iritis, transient myopic astigmatism is commonly present.

(3) *Tenderness of the Globe.*—This occurs even in uncomplicated iritis, especially of rheumatic origin, but if severe, suggests inflammation of the ciliary body.

(4) *Photophobia* and *Lachrymation.*—These symptoms vary considerably in degree, being almost or quite absent in some varieties, and severe in those of acute and violent onset.

(5) *Malaise*, fever, nausea, and marked depression, occasionally are experienced by the patient, the last often being the result of prolonged pain and insomnia.

Diagnosis.—The salient symptoms of iritis just detailed are sufficient for the purpose of diagnosis; nevertheless, it is not uncommon to find a case of iritis mistaken for some other external inflammation, and valuable time is lost by the useless application of astringent remedies. Most commonly, cases of simple iritis have been mistaken for one or the other types of conjunctivitis, and the following table may be found useful:—

Iritis.	Simple Conjunctivitis.	Phlyctenular Conjunctivitis.
1. Severe brow pain, worse at night.	Feeling of foreign body in the eye.	Acute general irritation.
2. Dim vision.	Vision usually unimpaired, unless secretion is very abundant.	Vision impaired by corneal involvement.
3. Fine pericorneal injection.	Coarse conjunctival injection.	Diffuse injection, with special lines of vessels running to phlyctenules.
4. Absence of secretion; some abnormal lachrymation.	Muco-purulent discharge; flakes of lymph.	Free lachrymation.
5. Sluggish or immobile pupil.	Pupil unaffected.	Pupil usually unaffected.
6. Iris discolored.	Iris unaffected in color.	Iris unaffected in color.
7. Abnormal reaction to mydriatic.	Normal reaction to mydriatic.	Normal reaction to mydriatic.
8. Severe photophobia exceptional.	Severe photophobia absent in simple cases.	Severe photophobia and blepharospasm.
9. Conjunctiva usually translucent; occasionally chemotic.	Conjunctiva opaque, velvety, and at times chemotic.	Conjunctiva translucent, bathed in tears.
10. Slight tenderness on pressure.	Tenderness not marked.	Tenderness not marked.
11. Posterior synechiæ.	No synechiæ.	No synechiæ.

Many variations in the types of iritis make it impossible to formulate unvarying rules for the establishment of a differential diagnosis, but attention to these points may prevent mistakes.

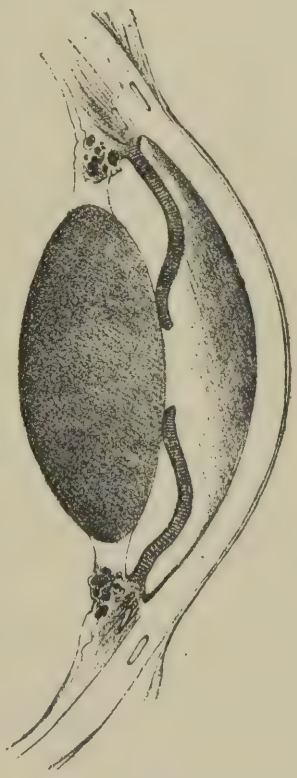
A diffuse scleritis somewhat resembles in its color the zone of pericorneal injection more or less characteristic of iritis, which, indeed, may be a complicating symptom of this disease. Acute glaucoma bears some resemblance to acute iritis (for the distinguishing points see page 378).

Course, Complications, and Prognosis.—An iritis may pursue an acute course, reaching its termination in four to eight weeks, or be chronic from its onset and last in a slow and insidious inflammation, for long periods of time. The termination of an iritis may be entirely favorable. The inflammatory adhesions disappear, and the iris regains complete mobility, only a few traces of iris pigment being seen on the capsule of the lens. On the other hand, more or less complete attachment causing

distortion and inequality of the pupil (consult Fig. 97) may remain; or deposits of exudate may directly occlude the pupil and lie upon the capsule of the lens.

The binding down of the iris throughout the whole extent of its pupillary edge, although the pupil itself remains clear, is denominated *exclusion of the pupil;* if the pupil is filled in with opaque inflammatory deposit, the term *occlusion of the pupil* is applied. With extensive or annular synechiæ the angle of the anterior chamber becomes obliterated, the iris is bulged forward except around its pupillary margin, which is bound down, so that a crater-like depression is evident, and the appearance denominated "*iris bombé*" is developed. (Fig. 98.) This leads to increased tension, secondary glaucoma, and even detachment of the retina, unless the communication between the anterior and posterior chambers of the eye is restored by operative measures.

Fig. 98.



Iris bombé in section (Berry). The iris has been bound down through the whole extent of the pupillary margin (exclusion of pupil). If the space between the points of iris-attachment, corresponding to the pupil, was filled in with exudate, occlusion of the pupil would be present.

The following tissues of the eyes may become involved during the course of an iritis: The cornea (*keratitis punctata*); the ciliary body (*irido-cyclitis*); the choroid (*irido-choroiditis*); the vitreous (*hyalitis*); and the optic nerve and retina (*hyperæmia*, or *neuro-retinitis*). With these facts in mind, and with the tendency of certain types of the disease to relapse, a prognosis must be guarded, but in uncomplicated iritis, seen early and properly treated, a perfect result may be obtained in the large majority of cases.

TREATMENT.—This depends upon several indications: (1) The suppression of pain by warm fomentations or dry heat, local blood-letting, and the internal administration of analgesics. (2) The maintenance of mydriasis by atropine. (3) The recognition of the cause and the exhibition of suitable internal medication, as well as the administration of remedies having the general physiological action of alteratives, even if the exact cause cannot be ascertained. (4) The use of surgical interference according to the indications. The description of the treatment in detail is reserved for the subsequent sections devoted to the particular consideration of the various types of iritis which follow.

Iritis is divided, according to its character and course, into *acute* and *chronic* iritis; according to its pathological nature, into *plastic*, *parenchymatous* and *serous* iritis; and according to its supposed etiology into *syphilitic*, *rheumatic*, *gouty*, *gonorrhœal*, *diabetic*, *tubercular*, *scrofulous*, *cachectic*, *idiopathic*, *traumatic*, *sympathetic*, and *secondary* iritis.

Simple Plastic Iritis runs an acute, subacute or chronic course, and is the most common form of the disease. The salient symptoms of iritis are present: discoloration of the iris, pericorneal injection, immobility of the pupil, and the formation of posterior synechiæ.

Not only may the ordinary attachments form between the iris and the capsule of the lens, but a plastic exudate may cover the pupil-space with a false membrane, and in some cases a gelatin-like mass is deposited in the anterior chamber. When this material consolidates, its appearance has been compared by Schmidt-Rimpler to that of a dislocated lens in the same position (*fibrinous or spongy iritis*). Plastic iritis is seen in—

1. *Syphilis. Syphilitic Plastic Iritis.*—When plastic iritis appears in the early stages of general syphilis, or in the stages of the mild exanthematous manifestations (the condylomata and the inflammations of the mucous membranes), it is not accompanied by characteristic clinical symptoms, which of themselves justify the diagnosis of syphilis.

The percentage of cases of syphilis which acquire iritis during the course of the disease, varies from 0.42 to 5.37 according to

different authorities; but among cases of iritis, syphilis has been found to be the cause in from 30 to 60 per cent. (Alexander.)

This form of iritis is common between the second and ninth month after the initial lesion, but may be delayed until the eighteenth month. Some authors have placed the appearance of plastic iritis in the gummatous stage of syphilis, but it is more probable that in such cases a few synechiæ, remaining from a plastic iritis in the early stages, have caused a relapse in this late period.

Commonly both eyes are attacked, one a little later than its fellow; occasionally the onset is simultaneous. The course usually is acute and after *thorough* cure, relapses are not common. A subacute or chronic type is also described.

Acute iritis of the plastic type is rare in new-born infants of syphilitic heritage; but has been described in children with inherited syphilis, from the second to the fifteenth month. There is much evidence to show that an acute iritis in children in the first months of life, and also in the later childhood years, always is the result of hereditary syphilis. In addition to the symptoms of severe plastic iritis, secondary involvement of the vitreous and ciliary body is liable to take place.[1]

In scrofulous and anæmic children, a form of iritis called *scrofulous iritis* has been described, which resembles the disease produced by inherited syphilis.

Treatment.—The most important local drug in this as in other forms of iritis is atropine (gr. iv–f℥j), several drops to be instilled into the conjunctival cul-de-sac every three or four hours according to the amount of pupillary immobility. If there is any associated conjunctivitis a boric-acid lotion may be added.

Pain is relieved and at the same time congestion is diminished, thus rendering the mydriatic action of the atropine more certain, by leeching the temple—one to three Swedish leeches being applied near the line of the hair, or blood is drawn by an artificial leech. In the absence of a regular Hourteloup this may be accomplished by making an incision in the temple with a scalpel

[1] Some authorities hold that in syphilitic iritis, change in the parenchyma of the iris with the formation of small nodes, in some instances undistinguishable by ordinary methods, is always present.

and using a small cupping-glass, to which a piston is attached for exhausting the air. Instead of using atropine in solution, some surgeons prefer to employ it incorporated with vaseline, or even to place a small quantity of the solid drug directly in contact with the cornea. Should atropine not be tolerated, hyoscyamine, hyoscine or duboisine may be substituted. The mydriatic effect of these drugs is somewhat increased by the addition of cocaine.

The constant use of atropine leads to disagreeable dryness of the throat. This may be obviated in part by compressing the tear-duct after each application. It may be relieved by giving the patient a gargle made of equal parts ice water and a strong decoction of coffee. Small doses of morphia are said to be of service, and pilocarpine and pellitory lozenges are useful.

Pain is further relieved by the application of moist or dry heat; the latter is best done by means of cotton batting which is held before a fire and then laid upon the affected eye, to be replaced by a freshly heated mass as soon as cooling occurs.

The best constitutional treatment is some form of mercury: either the protiodide, blue mass or calomel given, as in syphilis generally, just short of the point of salivation, and continued for many weeks even after all acute symptoms have subsided. When it is important to obtain rapid mercurial action, inunctions are advantageously practised. Hypodermic injections of mercury have been used by some surgeons. During the time that mercury is being pushed to the point of tolerance, the gums must be carefully watched for signs of sponginess, and the patient should frequently use a chlorate-of-potash mouth wash.

After the course of mercury, iodide of potash is indicated, for its own effect and for eliminating the mercury; later this may be combined with the bichloride of mercury. Quinine is sometimes added to the specific treatment, and the following formula will be found useful:—

Sulphate of quinine	2 grains.
Protiodide of mercury	$\frac{1}{4}$–$\frac{1}{2}$ grain.
Extract of hyoscyamine	$\frac{1}{4}$ grain.

Make one pill. One pill three times to six times daily.

In old syphilitics, with much cachexia, in whom a plastic iritis improperly treated in the early period has relapsed, it is

not always wise or possible to induce active mercurialization. Here the bichloride combined with the tincture of iron is a suitable remedy.

2. *Rheumatism. Rheumatic Iritis.*—This disease occasions iritis of a plastic form, or rather, rheumatism is a predisposing cause of many cases of iritis, in the opinion of some authors, (Berry) the rheumatic form being the most common of all the types.

It occurs between the ages of twenty and fifty, either with or without coincident rheumatic affections, and varies considerably in the aggressiveness of its symptoms. Not uncommonly these are severe, with much pericorneal injection, acute pain, greater usually than in syphilitic cases, and tenderness of the globe. Most frequently one eye is affected; the inflammation rarely is simultaneously symmetrical. The second iris becomes inflamed after a longer or shorter interval.

Relapses are frequent, in this particular differing from syphilitic plastic iritis, and a patient once having had an attack of rheumatic iritis is liable at intervals of months or even years, again to be attacked. If treatment is begun early, even in recurring attacks, perfect cure may be expected, as extensive exudation of lymph is uncommon.

The frequent relapses of rheumatic cases have given rise to the term *recurrent iritis*, applicable to some varieties.

A form of plastic iritis exists, aptly called "*quiet iritis*," in which there is no pain nor ciliary congestion, the only symptom being the progressive dimness of vision which leads to its discovery, and which is caused by rheumatism or inherited arthritic tendency in a majority of the cases, but which may also depend upon syphilis.

TREATMENT.—The use of atropine in the manner already described is of paramount importance. Leeches and moist and dry heat will help to relieve the pain. Frequently these measures will not be sufficient, and morphia, antipyrine, and antifebrin may be administered. Chloral alone will not relieve severe iritic pain, but its combination with antipyrine in the form of the remedy hypnal, in 15 grain doses, will produce sleep and allay pain.

Anti-rheumatic remedies are of great importance, and much

reliance may be placed upon salicylic acid, salicylate of soda, oil of gaultheria and the alkalies, the last, in the form of the mistura potassii citratis, being advantageously combined with tincture of aconite if restlessness and fever are associated symptoms.

The tendency of rheumatic iritis to recur, requires preventive treatment in the form of regulated diet, the use of mineral waters, and proper attention to change of clothing according to the vicissitudes of the climate.

In rheumatic iritis, which has assumed a chronic type, or if there has been exudation of lymph, or involvement of the ciliary body, mercury may be exhibited to obtain its alterative effect; for the same reason iodide of potash is required.

3. *Gout. Gouty Iritis.*—This resembles rheumatic iritis in its tendency to relapse and to attack one eye at a time. An iritis may reveal a gouty diathesis previously latent and unsuspected, and may appear as the first symptom of this affection, to be followed by an outbreak of gout elsewhere in the body.

A form of iritis, insidious in character and destructive in tendency, almost invariably associated with disease of the vitreous, occasionally occurs in children of gouty parents. These children, according to Mr. Hutchinson, have a peculiar squareness of build, heavy features, florid complexions, and feebleness of circulation in the extremities.

Treatment.—The usual measures to relieve pain and maintain mydriasis are indicated, together with appropriate anti-gout diet, citrate of lithium, salicylate of lithium, colchicum, iodide of potash and hypodermics of pilocarpine. Change of climate may be necessary. In the chronic cases, tonics are suitable remedies.

4. *Gonorrhœa. Gonorrhœal Iritis.*—This is a rare form of iritis, chiefly plastic in character, which usually does not coincide with nor follow the gonorrhœal attack; an arthritis of the knee, or sometimes of the ankle, intervenes. It has been explained by the influence of the gonococci on the iris. Like the rheumatic types, it is attended with severe pain, in addition to the usual symptoms of iritis. It may relapse with each new attack of gonorrhœa.

TREATMENT.—The local use of atropine, etc. If the urethra is inflamed this must receive attention ; but, as just stated, usually the gonorrhœa and the iritis do not coincide. The various alteratives, especially iodide of potassium, may be tried, and mercury, if there is much exudate. Relief will follow profuse sweats by means of pilocarpine given hypodermically, or in the form of the fluid extract of jaborandi.

5. *Diabetes. Diabetic Iritis.*—The subjects of diabetes may develop a plastic iritis, not only after an operation involving mutilation of the iris, but independently of any exciting cause. The disease is intractable and sometimes is complicated with hemorrhage into the anterior chamber. On account of the occasional association of diabetes and iritis, an examination of the urine is advisable in all cases of stubborn iritis.

TREATMENT.—This requires the usual local remedies for iritis, and the treatment suited to diabetes.

Parenchymatous Iritis is characterized by general or localized discoloration or swelling of the iris, owing to inflammation and cellular proliferation within its tissues.

The swelling may be general and the margin of the pupil tied down to the capsule of the lens by exudation; or small yellowish nodosities, crossed by vessels near their free borders, rise perceptibly above the level of the iris, and gradually shade away into its structure. The effusion into the parenchyma of the iris may become purulent, with filling up of the pupillary space and the formation of hypopyon. Parenchymatous iritis is seen in :—

1. *Syphilis—Syphilitic Parenchymatous Iritis; Iritis Papulosa; Gummatous Iritis.*—In the later secondary stage of syphilis a form of iritis occurs, differing from the plastic variety by the development of clinical features, characteristic of the disorder which has produced it.

This is indicated by the appearance in the inflamed iris, if it occurs during the course of a plastic iritis, or independently of this antecedent condition, of one or more yellowish, reddish-yellow, or reddish-brown nodules, varying in size from a hemp seed to a small pea, situated at the pupillary or ciliary border, or occasionally between the two, in the iris tissue. They are crossed

by fine vessels. They vary in number from one to four, the intervening iris tissue being comparatively unaffected, and belong, in spite of their resemblance to gummata, to a comparatively early period of syphilis. They are gradually absorbed without leaving distinct scars or atrophy of the iris tissue, to mark their former situation.

This is the so-called *gummatous iritis*, although some writers (Alexander) reserve this name for the formation of true gumma of the iris, and describe the present type as *iritis papulosa*.

Gumma of the iris, according to Alexander, appears almost constantly at the ciliary border, is solitary, of the size of a pea or small nut, grows toward the ciliary body, and disappears through fatty degeneration, leaving behind a permanent scar or atrophy of the iris. This appears in the so-called tertiary period of syphilis, or that period in which gummata in other organs are found.

The disease known under the name "gummatous iritis," or sometimes "true syphilitic iritis," is not common; Alexander, however, states that in more than 27 per cent. of iritis he has found that form of iris-change which is described by the general term "iritis gummosa."

Treatment.—The same treatment described in connection with syphilitic plastic iritis is applicable, and mercury should be pushed until complete absorption of the nodes has been obtained.

In true gumma of the iris, on the other hand, the free use of mercury is not always permissible owing to the cachectic state of the patient, and because more rapid absorption appears to take place under ascending doses of iodide of potash which may be given in a decoction of sarsaparilla.

Infectious Disease Iritis is seen in association with recurrent fever, pneumonia, typhus and typhoid fever, and a *purulent iritis*, as the result of embolism, occurs in the course of septicæmia after puerperal fever, and in pyæmia.

In malaria a periodic iritis with hypopyon has been described, and somewhat analogous to this is another periodic iritis, or iridocyclitis, which has been seen before each menstrual period (*iritis catamenalis*), perhaps due to abnormalities in the uterine discharge.

The management of such cases depends upon general principles, the free use of quinine and stimulants being appropriate in purulent iritis.

Idiopathic Iritis, or one in which no local injury or constitutional disease can be accredited with its origin, is rare in elderly people, occurs in adults, chiefly men, and has been described in children especially, in a slight plastic form, in girls nearing puberty.

Idiopathic iritis has been ascribed to cold, but often no cause can be given; it usually is monolateral.

Traumatic Iritis occurs as the result of an injury, either accidentally inflicted or made in the course of an operation; *e. g.*, cataract extraction.[1] In this category are placed, also, those cases of iritis which follow discission of the lens and the production of iritic inflammation by contact of the iris with the swelling cortical material. Most frequently the cause, when not brought about in the manner just stated, is infection carried directly into the wound.

Treatment.—The usual local measures are advisable, and if the inflammation is seen in the first stage of its development, iced compresses are suitable, for the same reason that they are applicable in wounds of the eyeball generally. These must not be used late in the disorder, nor in any other form of iritis.

Sympathetic Iritis (see page 337).

Secondary Iritis, or that form which appears with other diseases of the eye by the spread of the inflammation, is most commonly seen in association with diseases of the cornea which present themselves in the form of sloughing or perforating ulcers, and has been described in this connection. Scleritis of the deep variety is often associated with iritis.

More rarely the primary disease begins deep in the eye; *e. g.*, by detachment of the retina. The pressure of intraocular tumors occasions a secondary iritis.

The *treatment* consists in proper applications to the original disease, with such measures as are suitable under the circumstances

[1] Spongy iritis (page 316) is occasionally seen after cataract extractions (Knapp). Strong solutions of eserine may produce plastic iritis.

to relieve the iritis. The presence of iritis in corneal ulceration is one of the contraindications for eserine.

Serous Iritis (*Descemetitis, Aquo-Capsulitis, Keratitis Punctata, Serous Cyclitis*).—This affection has been described in part on page 290, and is characterized by a serous or more commonly a sero-plastic exudate, deepening of the anterior chamber, slight dilatation of the pupil (at least an uncontracted pupil), haziness of the cornea and aqueous humor, and a precipitate of opaque dots, upon the posterior elastic lamina of the cornea, generally arranged in a triangular manner, with the apex pointing upward. There is a slight pericorneal injection, no great tendency to form synechiæ, and the tension is apt to be higher than normal, at first, but later diminishes. Posterior synechiæ form later, and if they are extensive, secondary glaucoma.

In serous iritis, Collins has found pathological changes in the glands of the ciliary body, and hence the recommendation of Priestley Smith, that this disease be designated *serous cyclitis*, is appropriate.

Serous iritis is seen in association with disease of other portions of the eye, and appears as one of the manifestations of sympathetic ophthalmia (page 337). It occasionally seems to arise, like the other forms of iritis, from a true syphilitic basis in the early stages of this disease (Alexander). It is more common in women than in men. It has been observed with menstrual disorders in anæmic patients.

Treatment.—The rule, previously given, to maintain complete mydriasis with atropine, meets with an exception in this type of iritis. The drug must be applied with great caution, a continual watch being kept on the tension.

Diuretics, laxatives and diaphoretics are indicated. Iodide of potash acts well, and turpentine in full doses has found favor with some surgeons. Should a syphilitic origin be determined upon, the usual remedies are applicable.

Any rise of intraocular tension, unless extremely temporary, should be overcome by paracentesis corneæ. In the event of persisting increase of intraocular tension an iridectomy may be required.

Chronic Iritis.—Any type of iritis may assume an acute, subacute, or chronic course; if the last, no additional symptoms occur, but those ordinarily present are modified by the chronicity of the stages.

In addition to the chronic type of an ordinary iritis there remains to be described one which has received the name *plastic irido-choroiditis*, because of the complications of disease of the choroid and vitreous, leading to the formation of a secondary cataract. This disease occurs in adults, usually without assignable cause, is symmetrical and proceeds steadily in a tendency destructive to the nutrition of the eye. (See also page 334.)

The *treatment* of this condition is unsatisfactory, alteratives, tonics, and operative measures often meeting with indifferent success.

Operative Treatment in Iritis.—In ordinary acute iritis the tension does not rise. In serous iritis, continued elevation of tension indicates paracentesis.

Pure types of iritis are practically never complicated with the formation of hypopyon, although this is not uncommon with secondary iritis, and in irido-cyclitis. A cheesy or purulent detritus may partly fill the anterior chamber in gummatous iritis. In such cases the evacuation of the contents by Saemisch's operation would be appropriate.

An iridectomy may be needed in recurrent iritis, or in an iritis which refuses to heal completely, some ciliary injection and irritability remaining. It is a nice point to decide upon the appropriate cases for operation. Those cases which present the least change in the iris, in which the aqueous humor is clear and the tension is not subnormal, are most likely to yield a good result. Iridectomy in recurrent iritis of rheumatic type does not insure the patient against further attacks.

In chronic iritis, circular posterior synechiæ and bulging of the iris are the most important indications for the operation. Determined rise of tension and threatening glaucoma, under any circumstances, furnish reasons for its performance. According to Nettleship, keratitis punctata, chronic thickening of the iris with very extensive attachments, the existence of myopia, a tendency to spontaneous bleeding, and hypopyon render the

operation less desirable; if the tension is below the normal, the operation may be followed by bleeding and shrinking of the eyeball.

An iridectomy is performed to secure one or all of three ends: (*a*) Prevention of recurring attacks; (*b*) re-establishment of the communication between the anterior and posterior chambers of the eye, with consequent improvement in its nutrition and aversion of threatened glaucoma; (*c*) improvement in vision by the substitution of an artificial pupil for one that has been occluded or excluded.

The point for the operation must be determined in large measure by the condition of the iris, that portion being selected for excision which is least changed and least bound down by adhesions.

Before operating, great care should be exercised to note the tension, the state of the iris, and, if possible, of the deeper structures, and to obtain a map of the field of vision. If these examinations indicate much deep disease, strong reasons are present for declining to operate.

Posterior synechiæ remaining after the acute symptoms of iritis have subsided, have been regarded as a cause of relapse or recurrence, and, although this has not been proven, several operations have been devised for severing such attachments, to which the general term *corelysis* has been applied.

Tumors of the Iris—Cysts.—Cysts, having transparent, delicate walls lined with pavement epithelium, may develop in the iris, as the result of an injury, and may be situated in the substance of the iris, or have a superficial position. The diagnosis of cyst becomes very difficult if it is covered by a layer of iris-pigment. Cysts having solid contents are also described as having been produced by the passage of a cilium into the anterior chamber.

A cyst may be minute, or grow and fill the anterior chamber; both eyes may be affected, and some instances of multiple iris-cysts are on record. A cyst may cause irido-choroiditis and sympathetic ophthalmia by pressure. An attempt should be made to remove it through an incision, the growth and surrounding iris being seized, drawn out and excised.

Tubercle of the Iris (*Tubercular iritis*).—In a certain number of cases small grayish-red nodules develop at the margin of the pupil, bearing great similarity in their external appearance to miliary growths. Such growths may disappear, posterior synechiæ remaining at their points of origin, or successive developments of new nodules lead to a plastic inflammation of the iris and ciliary body, and shrinking of the eyeball. Under these circumstances tubercle of the iris appears in the form of an iritis.[1]

Tubercle of the iris also occurs in a *solitary form*, a yellowish nodule growing from the periphery of the iris, covered, it may be, with smaller bodies.

The average age of persons affected with primary tuberculosis of the iris, is twelve years; one or both eyes may be affected, more commonly the former. Although the patients may present no other signs of tuberculosis, this, and in a fatal form, may become a sequence. Bacilli and giant cells are found in these growths, proving their true nature. If operation is undertaken it should be the removal of the entire globe; iridectomy has been almost uniformly unsuccessful.

Fig. 99.



Sarcoma of the Iris. (Andrews.)

Sarcoma of the Iris (*Melano-sarcoma*) is rare as a primary disease. It is usually pigmented. At first of slow growth, later it increases rapidly with pain, hemorrhage, etc., and finally bursts forward through rupture of the globe. It is most common in females, and usually occurs between 20 and 40, the lower part of the iris being generally affected. (Fig. 99.)

It is noteworthy that in a number of

[1] In the opinion of certain authors these small tumors should not be regarded as tubercles of the iris, and have received the name *granulomata*, a term also applied to prolapses of the iris which are covered with granulation tissue.

instances, sarcoma of the iris has supervened upon simple *melanoma* of the iris. This latter is a dark tumor, developed from the pigment stroma of the iris, and commonly passive and innocuous, is occasionally in another form, as just stated, the precursor of sarcoma.

An exceedingly rare tumor is the non-pigmented iris-sarcoma (*leuco-sarcoma*). This may be complicated with serous iritis.

In the early stages, when the growth is circumscribed, favorable results follow excision of the diseased portion of the iris; later enucleation of the globe is necessary.

Very rare forms of iris tumor are vascular growths (nævi); leprosy nodules, and lipomata (Meyer).

Injuries to the Iris.— *Wounds.*—An incised wound limited to the iris does not necessarily produce serious results. It will be followed by blood in the anterior chamber, which in course of time is absorbed. Wounds, however, are rarely limited to the iris, but having penetrated the ball through the cornea or ciliary region, lead to the danger of sympathetic irritation, or injure the lens, and produce traumatic cataract.

In the first instance atropine, to secure physiological rest of the iris, and a compressing bandage, will lead to a speedy cure; in the other instances the extent and position of the wound will determine the necessity for enucleation, or for the treatment applicable to traumatic iritis.

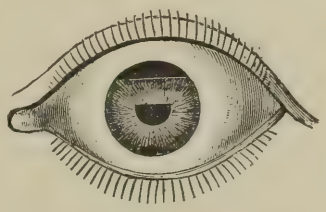
Foreign Bodies.—A foreign body may penetrate the cornea and lodge upon the iris, or having partially penetrated the cornea, may be pushed through it in the efforts at dislodgment, and become entangled in the iris. In either event it should be removed.

An opening is made with a broad needle, or narrow keratome, at the corneo-scleral junction, eserine having been previously instilled, and a pair of forceps passed into the wound with which the body is seized. If this is not possible, the piece of iris upon which the substance lies should be drawn through the wound and excised.

Certain injuries to the iris are produced by the effects of blows upon the eye, and are described under the following names :—

Irido-dialysis, or a rupture of the ciliary attachment of the iris (ligamentum pectinatum). By this means an opening is produced, comparable to a false pupil; it may be detected by the red reflex which shines through the artificial aperture, usually somewhat semi-lunar-shaped, situated in the periphery of the iris at the corneo-scleral margin. (Fig. 100.) This may be quite small or involve more than half the circumference.

Fig. 100.



Irido-dialysis. (Swanzy.)

In a few instances, re-attachment of the ruptured fibres has taken place under the favoring influence of atropine, which should be vigorously instilled. Ordinarily the lesion is permanent, and, if small, occasions little trouble, although there may be diplopia. Pain, some dread of light and hemorrhage into the anterior chamber, are the immediate sequences of such an accident.

Rupture of the sphincter produces mydriasis, and according to some authorities the not uncommon dilatation of the pupil (*traumatic mydriasis*), which follows a blow, is always accompanied by such a lesion. The condition is not altered by treatment.

Displacement of the iris occurs under three forms: (1) *Retroflexion*, or a folding back of a portion of the iris upon the ciliary processes, usually accompanied by a partial dislocation of the lens; (2) *anteversion*, or turning upon itself of the detached portion of the iris, so that the under or uveal surface is exposed; and (3) *aniridia*, or complete detachment of the iris from its insertion, so that it lies in the anterior chamber, or even under the conjunctiva. An injury severe enough to produce this condition, will usually be attended by other serious lesions of the remaining structures of the eye.

Anomalies of the Anterior Chamber.

(a) *Alterations in its Depth.*—These are seen under a variety of conditions. Physiologically the anterior chamber is shallower in

infancy and old age, and diminishes in its middle depth during the act of accommodation.

Pathological *deepening* of the anterior chamber occurs in luxation or absence of the lens, in serous iritis and some cases of cyclitis, and is present in conical cornea and certain forms of staphyloma.

Pathological *shallowing* of the anterior chamber occurs in chronic iritis with bulging forward of the iris, in glaucoma, and in the later stages of growths of the interior of the eye. Its depth is also lessened when there is diminution of the secretion of aqueous humor, in old cases of inflammation of the uveal tract with detachment of the retina.

(b) *Alterations in its Contents.*—These may consist in mere turbidity of the aqueous as in iritis, keratitis punctata, and glaucoma, or there may be a positive collection of pus, several times referred to under the name of *hypopyon*, and commonly seen in sloughing ulcers of the cornea and purulent inflammations of the iris and ciliary body.

Finally blood collects in the anterior chamber, a condition which receives the name *hyphæma*. This follows injury to the iris, accidentally or designedly induced, and occurs in tumors of the eye, hemorrhagic glaucoma, and in severe forms of iritis and cyclitis. It is also seen in hæmophilia.

(c) *Foreign Bodies and Parasites.*—A foreign body penetrating the cornea, may lodge upon the iris or fall into the anterior chamber. This may be a sliver of iron or steel, or a particle of glass. Sometimes a cilium passing through a wound obtains entrance into the anterior chamber.

The two parasites described in this situation are *cysticercus* and *filaria sanguinis hominis*. In all these instances the intruder should be removed by an operation.

CHAPTER X.

DISEASES OF THE CILIARY BODY, AND SYMPATHETIC IRRITATION AND INFLAMMATION.

Cyclitis.—Under the general term *cyclitis* are included various types of inflammation of the ciliary body. The close anatomical connection of the iris, choroid, and ciliary body makes diseases limited strictly to the last structure, exceedingly uncommon, just as in many instances inflammations primary in the iris or choroid, also involve the ciliary body. Hence when the iris and ciliary body are associated in pathological changes the term *irido-cyclitis* is applicable.

Symptoms.—The symptoms which in general lead to the diagnosis of cyclitis are the following: Injection of the circumcorneal or ciliary zone, neuralgic pain, and tenderness on pressure in this region; change in the aqueous humor which grows turbid; precipitates of exudation in grayish-brown points upon the posterior layer of the cornea, and at times hypopyon; exudation in the posterior chamber attaching the under surface of the iris to the lens capsule in a complete posterior synechia, the retraction thus produced causing a deepening of the anterior chamber; exudation into the vitreous causing opacities, especially in its anterior layers; and alterations in the tension of the globe, which may be increased or decreased.

The *general symptoms* of pain, photophobia, lachrymation, etc., are present in the acute types of the disease, and vision is seriously impaired according to the amount of the exudation in the pupillary space and vitreous. The following table, copied from Fuchs, may enable the student to differentiate between cases of pure iritis, and cases in which inflammation of the ciliary body predominates:—

Iritis.	Irido-Cyclitis.
1. Absence of unusual inflammatory phenomena.	1. Severe inflammatory phenomena, œdema of upper lid.
2. No decided tenderness on pressure.	2. Distinct tenderness on pressure.
3. No distinct changes in the anterior chamber; only slight turbidity of aqueous.	3. Precipitates in the cornea; retraction of the periphery or the iris by total posterior synechiæ and deepening of the anterior chamber.
4. Vision diminished in proportion to turbidity of aqueous.	4. Marked lessening of visual acuity due to opacities in the vitreous.
5. Unaltered intraocular tension.	5. Tension altered—lowered or raised.

Varieties of Cyclitis.—Systematic writers divide cyclitis into three varieties: *Simple* or *plastic*, *serous* and *purulent* cyclitis.

1. *Simple, or Plastic Cyclitis*, is characterized by severe ciliary pain and considerable pericorneal injection. The veins of the iris are dilated, its periphery is retracted by the action of the plastic exudate in the ciliary body, so that the pupil is dilated, or the anterior chamber is deepened. If the inflammation extends, the hyperæmia of the iris becomes an inflammation, the choroid is involved, and opacities form in the vitreous.

2. *Serous Cyclitis* is characterized by slight pericorneal injection and is unattended by severe pain. In the beginning, the pupil is dilated, the anterior chamber deepened, the aqueous somewhat turbid, and precipitates form upon the posterior layer of the cornea. (See *Serous Iritis* and *Keratitis Punctata.*)

There is decided diminution of vision and the rapid formation of fine opacities in the vitreous chamber in its anterior portion. Very commonly the iris is involved (serous iritis), as well as the choroid. This leads to increased tension, narrowing of the previously deepened anterior chamber, and the symptoms of glaucoma.

3. *Purulent Cyclitis* is characterized by intense ciliary pain, great pericorneal injection, and œdema of the conjunctiva and the upper lid. The vitreous becomes filled with large opacities, and a noteworthy feature is the formation of hypopyon, which may disappear and reappear again in a few days, its reappearance sometimes being signalled by a fresh exacerbation of intense pain. The iris and choroid commonly are included in the inflam-

mation, the former both in a purulent and parenchymatous type, and the latter in a suppurative form.

Course and Sequels.—Any form of cyclitis under vigorous treatment begun early, may terminate in healing and leave a useful eye. But the *prognosis* is always grave, because the disease, especially in the serous form, is liable to originate glaucoma, and in the purulent form, or in the plastic variety which has become purulent, tends to produce atrophy of the iris and choroid. The vitreous becomes filled with organic opacities, and by its contraction causes retinal detachment; opacity of the lens and shrinking of the eyeball follow, or that condition known as *phthisis bulbi*.

Shrunken balls of this character are often tender, readily become inflamed, and may produce sympathetic inflammation in the fellow eye; this is particularly true if the original inflammation has been a cyclitis of the plastic type, which in these instances probably remains in a *chronic* state.

Causes.—As already stated, primary and uncomplicated disease of the ciliary body is rare. The affection usually is part of a diseased process which involves the choroid or iris.

Injuries are common causes of cyclitis, and the inflammation may follow operations upon the globe, *e. g.*, cataract extraction. Syphilis attacks the ciliary body almost exclusively in the course of one of the forms of iritis, or in connection with disease of the choroid. In a few instances gummata, strictly confined to the ciliary body, have been described. Cyclitis, the result of gout in a previous generation, has been recorded.

Treatment.—The principles already enunciated in connection with iritis, apply to the treatment of cyclitis, and need not be repeated.

Injuries of the Ciliary Body.—The dangers attending perforating wounds of the sclera have been described on page 305; this danger is doubly increased when the wound occurs in any portion of a zone, one-quarter of an inch wide, surrounding the cornea, a region commonly called the "dangerous zone," after Mr. Nettleship's apt description. All of the consequences of the primary infliction of the wound are present, in addition to the danger of plastic cyclitis and sympathetic inflammation.

After a penetrating wound in this region two courses are open to the surgeon—an attempt to save the eye, or immediate enucleation. If an attempt be made on the side of conservatism, the plan discussed in scleral wounds (page 305) should be employed ; if not, enucleation or a substitute for this is needed. The rules for this appear on page 340.

Tumors of the Ciliary Body.—Round-celled sarcoma and myxo-sarcoma have been described in this region. The former may not seriously impair the functions of the eye in its earlier stages, but as soon as the nature of the growth—which first appears as a brown mass behind the iris, rarely in the angle of the anterior chamber—is known, the globe should be enucleated.

Gummata of the ciliary body have been referred to, and rarely are limited strictly to this region. Ossification of this structure has been recorded.

Irido-choroiditis (*Cyclitis with Disease of the Vitreous and Keratitis Punctata ; Chronic Serous Irido-choroiditis*).—Under the above names a disease of the eye is recognized, which, following Meyer's classification, is divided into two forms, according as the affection is primary in the iris or in the choroid.

In the first instance there are mild iritis, insignificant pain and ciliary congestion, deepening of the anterior chamber, and spots in the posterior layer of the cornea as in serous iritis and keratitis punctata. The chronic inflammation continues, relapses take place, exudation occurs behind the iris, while its pupillary margin is bound down so that the surface is irregularly or entirely bulged forward, and, if the pupil is not too much occluded, the ophthalmoscope will reveal flocculi in the vitreous. The tension may now become raised and the eye pass into secondary glaucoma.

In the other type the process passes from behind forward, beginning with patches of choroiditis, which increase in extent and depth, the nutrition of the vitreous is impaired and opacities form, the lens is altered and pushed forward, the iris becomes embodied in a plastic inflammation, with narrowing of the anterior chamber and marked loss of vision. As the disease of the

uveal tract continues the lens becomes opaque, the eyeball softens, the retina may be detached, and finally shrinking or phthisis occurs.

This disease is chronic in course, and the symptoms, especially those confined to the iris, are insidious. A cure may be obtained in the earlier stages, but the danger is the production of glaucoma through rise of tension, or atrophy and shrinking of the ball from extension of the morbid process.

This affection usually occurs in young adults, and commonly is symmetrical. It has been attributed to inherited gout, to rheumatism and to syphilis. It also occurs from prolonged work associated with loss of sleep, from defective nutrition, and in women, apparently due to menstrual irregularities. In other instances no assignable cause is present, or the disease has started as the result of synechiæ from a former iritis.

TREATMENT.—In the earlier stages atropine, provided there is no rise of tension, should be employed ; in the event of increased tension without synechiæ, cocaine and eserine may be used.

Internally, mercury by inunction is indicated, if the patient is robust, but in the form of the bichloride combined with iron, if there is anæmia. Iodide of potash may also be tried.

When the presence of firm posterior synechiæ has blocked the communication between the anterior and posterior chamber, this should be reopened by a good peripheral iridectomy, which, if the lens is opaque, may be combined with its extraction. Even in eyes in which softening has begun, provided the field of vision still remains intact, good results will sometimes follow a successful iridectomy. (Meyer.)

SYMPATHETIC IRRITATION, AND SYMPATHETIC INFLAMMATION OR OPHTHALMITIS.

These terms are applied to affections in which one eye is implicated as the result of disease or injury to the other, and represent two essentially different conditions.

It is customary to describe the eye which is implicated as the result of the disease or injury of its fellow as the *sympathizing*

eye, and the one affected by the disease or injury which causes the implication the *exciting* eye.

Conditions Producing Sympathetic Affections.—According to Alt,[1] the entire nervous apparatus of the diseased eye participates in the transmission of the affection to the other. Generally one or other of the following conditions is present:—

(*a*) Punctured wounds of the ciliary region which set up a traumatic irido-cyclitis. This ciliary region is the zone previously described under the term borrowed from Mr. Nettleship, "dangerous zone." Traumatisms probably cause over 80 per cent. of the cases of sympathetic inflammation.

(*b*) Foreign bodies in the eye.

(*c*) Perforating wounds or ulcers of the cornea in which the iris has become incarcerated, or scars involving the ciliary body.

(*d*) Operations upon the eye—extraction of cataract, sclerotomy, iridodesis, iridectomy, discission, and reclination, the last, of course, being a cause now practically eliminated.

(*e*) Luxation, wounds and calcification of the lens.

(*f*) Intraocular tumors.

(*g*) Ossification and calcification of the choroid and ciliary body.

(*h*) Pressure of an artificial eye or incarceration of the stump of the optic nerve in scar tissue, after the operation of enucleation.

Sympathetic Irritation (*Sympathetic neurosis*) is a functional disturbance, which presents a series of symptoms, comprising photophobia, lachrymation, blepharospasm, defective or impaired accommodation, lessened visual acuity, inability to perform close work, neuralgic pain through the distribution of the supraorbital nerve, photopsia, contraction of the field of vision and hyperæmia of the eye-ground.

With this there may be some tenderness or pressure over the ciliary region. Hence when observing an eye so affected that it is likely to produce either sympathetic irritation or sympathetic inflammation it is most important to watch for tenderness in the

[1] It is stated that eyes which are, or have been, the subjects of purulent panophthalmitis do not produce sympathetic ophthalmia. Alt, however, in his analysis of more than one hundred cases, found thirteen eyes enucleated for sympathetic irido-choroiditis, the other having been lost by purulent panophthalmitis.

ciliary region, to measure the amplitude of accommodation, and to examine the field of vision. The tendency of this condition, which is looked upon as a neurosis, is to recur. It disappears entirely with the removal of the exciting eye.

Symptoms in the Eye Exciting Sympathetic Irritation.—An eye so injured or diseased, that it is liable to produce the condition described in the preceding paragraphs, is apt to show, during the course of the irritation, attacks of congestion in the ciliary region, photophobia, tenderness on pressure, lachrymation and neuralgic pain. These may subside, just as the sympathetic irritation in the fellow eye may subside, and recur again and again. Patients when questioned will state that they have had one or more attacks of "sore eyes."

Sympathetic Inflammation (*Sympathetic ophthalmitis*) occurs in several forms, sometimes arising in the wake of an attack of irritation, but more frequently without any premonition of this character. None the less, if patients have had sympathetic irritation, it is proper to warn them that this may pass on to irremediable structural changes. On the authority of Mr. Gunn, it is stated by Nettleship, that marked oscillation of the iris often occurs when a sympathetic irritation is about to give place to an inflammation.

With or without warning, sympathetic ophthalmitis, or, as it is sometimes called, *uveitis*, presents itself:

(1) As an *irido-cyclitis*, or an inflammation characterized by pain, photophobia, pericorneal congestion, discoloration of the iris, closure of the pupil by exudation around its margin and behind the iris, tenderness over the ciliary region, narrowing of the anterior chamber, effusion into the vitreous, opacity of the lens, detachment of the retina, and finally shrinking of the eyeball.

(2) As a *serous iritis* having the symptoms already described with this affection, namely turbidity of the aqueous, deepening of the anterior chamber, punctate opacities on the posterior layer of the cornea, rise in tension, slight ciliary injection, and some opacity in the anterior layers of the vitreous. Not infrequently, if not in all of the cases, there is at the beginning a *neuro-*

retinitis, which, however, is not the first symptom calling attention to the disease.

(3) As a *choroido-retinitis* in which the outlines of the papilla are hazy, the retina œdematous, the retinal veins dilated and tortuous, with or without the appearances of slight serous iritis. This is a rare manifestation.

These symptoms in the sympathizing eye may be either *acute* or *chronic*. Often they come on insidiously and are not discovered by the patient until serious damage has been done. A premonitory symptom of great importance, and one which should always be searched for in cases in which sympathetic irritation or inflammation is likely to take place, is an almost characteristic tenderness in the ciliary region, frequently in a circumscribed spot, which may be picked out with the end of a probe. When this is pressed upon, the patient shrinks from the touch in a peculiar and striking manner. Sometimes an exactly similar tender spot is found in the ciliary region of the exciting eye.

Symptoms in the Eye Exciting Sympathetic Ophthalmitis.—Preceding the development of any of the types of sympathetic ophthalmitis, the exciting eye usually presents obvious iritis or iridocyclitis, congestion, and alteration in the tension; but, as has been often pointed out, it is important to remember that the local manifestations in the exciting eye may not be characterized by great pain, and consequently may escape attention, and although necessarily the vision is disturbed, the eye need not be a blind one, and, indeed, may be the one which will recover with the better vision of the two.

The Period of Incubation.—The period of incubation, or that period of time between the reception of the injury or disease in the exciting eye and the development of inflammation in the sympathizing eye, varies considerably, in the majority of cases being from three to six weeks. Exceptionally, the disease begins as early as the seventh day and has been postponed as late as twenty or thirty years, in Alt's collection one case being stated to have occurred as late as sixty years after the exciting disease.

Sympathetic irritation may arise within a very few days after

the reception of an injury. It has occurred within the first forty-eight hours.

Nature of Sympathetic Ophthalmitis.—Formerly it was almost universally thought that this disease was due to a reflex action through the ciliary nerves, and on this theory the name "sympathetic" was applied. The exact nature of this grave malady is not perfectly known, nor is the path of the morbid changes which precede the inflammation, fully mapped out.

The old hypothesis of transmission by the ciliary nerves, however, has largely been abandoned for the *theory of infection*, and in the belief of many, the route of the micro-organisms is by the way of the sheaths of both optic nerves, experimental research, especially by Deutschmann, having demonstrated the anatomical possibility of such transmission. The belief in this propagation to the sympathizing eye, by direct continuity through the optic nerves and chiasm from the exciting eye, has led to the adoption by some writers of the term proposed by Deutschmann—*migratory ophthalmitis.*

Although the weight of evidence tends to the acceptance of this belief, it is none the less true that there is anatomical proof of the existence of sympathetic ophthalmia in man, without the alteration of the optic nerves, and consequently a transmission by the ciliary nerves, or by some other avenue, must be considered. (Meyer.)

Treatment.—The most important consideration is *prophylaxis*, or, in other words, the management of the eye originally affected. This depends upon the character and situation of the wound, or upon the stage of the disease, and upon the amount of vision possessed by the injured or diseased organ.

In the section devoted to treatment of wounds of the sclera, the method was pointed out by which eyes seriously wounded might be saved.

It may sometimes happen, especially in private practice, where every advantage of nursing and careful watching is at hand, that eyes may be saved which would be sacrificed in the working classes. The attempt requires the gravest thought before it is undertaken, because the onset of a sympathetic ophthalmitis may be insidious, and when once begun no treatment can fully remove

the structural changes which have taken place. The propriety of operating must be determined by regarding the following rules, which are modified from those given by Swanzy, and represent the published experiences of the best authorities.

Enucleation, or one of its substitutes, should be performed on—

1. An eye with a wound so situated as to involve the ciliary region, and so extensive as to destroy sight immediately, or to make its ultimate destruction by inflammation of the iris and ciliary body reasonably certain.

2. An eye with a wound in this region already complicated by severe inflammation of the iris or ciliary body, even if sight is not destroyed.

3. An eye containing a foreign body which judicious efforts have failed to extract, and in which severe iritis is present, even if sight is not destroyed.

4. An eye, the vision of which has been destroyed by plastic irido-cyclitis, or one which has atrophied or shrunken, provided in either case, there is tenderness on pressure in the ciliary region and attacks of recurring irritation.

5. An eye whose sight has been destroyed, even though sympathetic inflammation has begun in the sympathizing eye, in the hope of removing a source of irritation and thus rendering treatment to the second eye more effectual.[1]

6. An eye in which the wound has involved the cornea, iris, or ciliary region, either with or without injury to the lens, and in which persistent sympathetic irritation in the fellow eye has occurred, or in which there have been repeated relapses of sympathetic irritation.

7. An eye either primarily lost by injury or in a state of atrophy, associated with signs of sympathetic irritation in the fellow eye.

It is universally conceded that the enucleation of an eye primarily injured, the visual function of which cannot be restored, is the surest way of preventing sympathetic ophthalmitis. It is to be remembered, however, that even a very early enu-

[1] This rule is not adhered to by some surgeons, because it is believed by them that no good results will follow.

cleation does not necessarily prevent sympathy in the fellow eye, because the infective process may have begun before the operation, and may not develop for several weeks.

If sympathetic inflammation has begun, the rules just quoted are not applicable, and enucleation must not be performed if there is any vision in the exciting eye, which in the end may prove to be the more useful organ. The same principles of treatment already enunciated in regard to iritis and irido-cyclitis are applicable.

In the treatment of the sympathetically affected eye, operation usually has no place. Both iridectomy and sclerotomy have been advised, but it is better to await the subsidence of acute symptoms before attempting any surgical interference unless the intraocular tension be inordinately raised, and then scleral incision may be practised.

The *general treatment* consists in confinement in a darkened room (moderate exercise with eyes well bandaged, is permissible in subjects failing for lack of it); complete functional rest of the eyes and atropine locally, provided there is no rise of tension and no atropine irritation; and leeches to the temple, if the inflammation is florid. In robust subjects mercurial inunctions are useful; in more debilitated cases a course of tonics and alteratives is advisable; under any circumstances full doses of quinine should be exhibited.

Under such treatment the affected eye will either recover with useful sight, pass into atrophy or phthisis bulbi, or grow quiet, with the formation of complete annular adhesions of the iris to the capsule of the lens, which has become cataractous.

To improve vision under the last-named condition, iridectomy has been tried, but the results are unfavorable. It has hence been combined with extraction of the cataractous lens. This operation also presents serious difficulties. Finally, the method proposed by the late Mr. Critchett, of dividing the capsule with one or two cutting needles, care being taken to avoid wounding the iris, has been advocated, provided it is a young eye which is under treatment.

Prognosis.—The prognosis of sympathetic ophthalmitis is

essentially grave. In some instances recovery occurs; this has been seen in those instances in which neuro-retinitis is present.

More frequently, especially in the forms which appear as an irido-cyclitis or irido-choroiditis, the sight of the eye is lost, and the organ shrinks. The varieties which appear as a serous iritis give the greatest hope for a good result. It is extremely important to warn patients of the grave nature of this malady, and if an attempt is made to save an eye injured in the way already described, it must be done with the full understanding of the serious risks which are undertaken.

CHAPTER XI.

DISEASES OF THE CHOROID.

Congenital Anomalies.—Two striking congenital anomalies occur in connection with the choroid :—

1. *Coloboma of Choroid* is a large defect in the choroid, almost always in its lower part, and often associated with a similar vice of conformation in the iris.

Examined with the ophthalmoscope the deficient area appears as a glistening pearl-colored patch, often irregular on its surface, owing to the development of several protrusions and corresponding intervening depressions, and bordered by an irregular pigment line. The retina may be recognized as a translucent veil covering the defect, and the retinal vessels occasionally pass into the depressions. The coloboma may include the optic nerve entrance, either partially or completely, or may be separated from it by a bridge of healthy choroid. It may be confined to the area around the disc, or pass downward as far as it can be followed, and be connected with a similar defect in the iris from which it is separated by a band of choroid tissue.

Coloboma of the choroid is seen also without coloboma of the iris. It is due to imperfect closure of the ocular cleft (choroidal fissure).

In addition to coloboma in the usual situations, similar defects have been described in the macular region (*macular coloboma*) and the nasal half of the eye-ground, and for these defects, which do not involve the optic disc, Johnson has proposed the name *extra-papillary coloboma*. Macular colobomata have been explained on the theory of intrauterine choroiditis, but Johnson thinks they present many points in common with cutaneous nævi, and may be looked upon as the atrophied remains of nævoid growths in the choroid.

2. *Albinism*, or a congenital want of pigment in the choroid

and iris, is a deformity met with both in a *complete* and *incomplete* form.

The iris has a pink, or pink and yellow appearance, due to the reflection of light from its own bloodvessels and from those of the choroid, which, in the most pronounced forms of the defect, can be seen with the ophthalmoscope, down to their finer branches. The anomaly is most marked in early childhood, is almost invariably associated with lack of pigmentation in the hair, and is accompanied by nystagmus, a certain amount of amblyopia, and the presence of high grades of refractive defects. In many instances albinism has been observed in several members of the same family, and seems to be hereditary.

Hyperæmia of the Choroid.—It is extremely doubtful whether an ophthalmoscopic examination can demonstrate hyperæmia of the choroid, just as later we shall see that such a condition of the retina is difficult of diagnosis. An actual hyperæmia could fairly be shown to exist, only by finding a real distension of the vessels of the choroid, which usually are invisible, and the *congestion of the choroid*, described with myopic or asthenopic eyes, and as the result of exposure to bright light and heat, is more often a figure of speech than a proven pathological condition. The student should be on his guard not to mistake an exposure of the choroidal vessels by absorption of the pigment epithelium, for a condition of hyperæmia.

Nevertheless, in eyes subjected to prolonged strain, the result of uncorrected ametropia, certain changes in the normal appearance of the fundus arise, which are usually described under the vague term "choroidal disturbance." We may assume hyperæmia, when the nerve-head presents distinct redness, which is imperfectly differentiated from the unduly flannel-red appearance of the surrounding choroid, or when the choroid, instead of exhibiting its usual uniform red color, has changed into what has been denominated a "woolly choroid," with faint dark areas in the periphery, indicating the interspaces between the choroidal vessels, and more or less pronounced retinal striation surrounds the disc. This is a familiar picture in many cases of "eye-strain."

Treatment.—In this condition, often associated with the subjective symptoms of aching eyes, some intolerance of artificial

light, and distinct asthenopia, the eye should be atropinized, dark glasses should be worn, and when the irritable condition of the fundus has sufficiently subsided, a proper correction of the refractive error should be ordered.

As an adjuvant to the local use of the atropine, the internal exhibition of small doses of iodide of soda, bromide of potash, and fluid extract of ergot serve a useful purpose.

Choroiditis.—Under the general term *choroiditis*, are included various types of inflammation of the choroid which may be (*a*) idiopathic; (*b*) part of the symptomatology of disorders in other portions of the uveal tract, or indicative of general disease; and (*c*) traumatic.

Symptoms.—Certain symptoms, for the most part revealed only by the ophthalmoscope, are present:—

1. Alteration in the uniform dull-red surface of the eye-ground caused by (*a*) the absorption of the pigment epithelium; (*b*) patches of pale-yellow color with ill-defined boundaries due to exudate (*recent choroiditis*); (*c*) patches of white color due to exposure of the underlying sclerotic (*atrophic choroiditis*); and (*d*) patches of black pigment, variously shaped, scattered over the fundus, and usually bounding the spots of atrophy (*pigment heaping*).

2. Absence of external manifestations indicative of the deep-seated disease, except when acute and purulent forms, in which the diseased process is not localized in the choroid, are accompanied by injection, chemosis of the conjunctiva, etc.

3. Changes in the transparent media (lens, vitreous) by the formation of opacities, as a secondary result of the choroidal disease.

Subjective symptoms peculiar to choroiditis do not exist.

Pain usually is not present except in purulent forms, and in such varieties as may be complicated with iritis.

Disturbance of vision is in direct relation to the situation of the lesions and the amount of atrophy. If the choroidal disease is peripheral, visual acuity may be unaffected; if atrophic patches occupy the macular region, sight may be greatly diminished, or practically obliterated. It is remarkable, however, that even in extensive diffuse choroiditis good vision may still be present. If

the disease has caused secondary changes in the vitreous or lens, these add to the depreciation of visual acuity.

Scotomata, both positive and negative, may be present. Contraction of the field of vision is found in certain types of choroiditis, and especially if secondary atrophy of the optic nerve has occurred.

Diagnosis.—This is readily made by observing with the ophthalmoscope, the appearances briefly summarized in paragraph 1 of the general symptoms.

Inasmuch as choroiditis, in the large majority of cases, is complicated with secondary retinitis, it is difficult to decide whether the pigment lies in the choroid or retina. If the pigment mass is covered by a retinal vessel, and at the same time is situated in a deeper layer than this, its position is judged to be in the choroid; if the retinal vessel is covered by the pigment mass, and the latter is situated more anteriorly, its position is assumed to be in the inner surface of the retina, to which spot it has wandered through secondary involvement of the retina. Pigment characterized by a "lace-like pattern," or resembling bone corpuscles, is always in the retina. (Nettleship.) A commingling of these positions in the same eye-ground is common.

Course, Complications, and Prognosis.—A choroiditis may be sudden in onset and pursue an acute course; for example, an acute choroiditis at the posterior pole of the eye resulting in a permanent myopia, or in the purulent forms of the disease.

More commonly the course of choroiditis is slow and chronic. Beginning with exudation or hemorrhage, it passes by slow stages through the period of absorption, atrophy, and pigment accumulation. It is by the last signs a former choroiditis is recognized, and the changes are called "old choroiditis," or "choroido-retinitis."

The following structures are liable to become involved during the course of a choroiditis: The retina, which from its intimate association with the choroid through the pigment epithelium, probably does not escape in any instance, and in many the association of disease is so close that we apply the term *choroido-retinitis* or *retino-choroiditis;* the optic nerve (*choroiditic atrophy*); the vitreous (*vitreous opacities*); the crystalline lens (*posterior*

polar cataract); the iris (*irido-choroiditis*); and the sclerotic (*sclerotico-choroiditis*).

The *prognosis* in choroiditis is always grave, and although careful nursing may preserve sight, in many instances great loss of vision and entire blindness may ensue. Necessarily the prognosis as to vision depends upon the position of the disease and its relation to the macula.

Treatment.—This in general terms demands perfect rest for the affected eye, blood-letting from the temple in the early stages, protection from glaring light, and the administration of alteratives, the iodides and mercurials, especially if there is any reason to suspect syphilis. Further details will be reserved for the sections devoted to the several varieties of choroiditis.

As already stated, choroiditis may be acute or chronic, and, like iritis, has been divided, according to its pathological nature, into *plastic*, *serous*, and *purulent* forms. In like manner, when the cause of choroiditis is definitely known, it is customary to indicate this in the terminology, *e. g.*, syphilitic choroiditis.

For the present purpose choroiditis may be divided into *superficial* and *deep* choroiditis, and a well-recognized classification may be adopted, which places all forms under one of two heads: (1) *Non-suppurative exudative choroiditis*, and (2) *Suppurative choroiditis* and *irido-choroiditis*.

Superficial Choroiditis (*Epithelial Choroiditis*).—Instead of the general dull-red appearance of the eye-ground, the larger vessels may be manifest as rather broad, reddish, or yellowish-red stripes, which traverse the fundus in an interlacing manner, and between which are the dark intervascular spaces, many of them having a lozenge-shaped appearance. This is due to the absorption of the pigment epithelium and the capillary layer which lies just beneath it.

In certain instances it is physiological, and is commonly seen in the periphery of eye-grounds, often by preference occupying a space down and in from the disc.

It may be universal, the only portion of the eye-ground escaping being the region directly confined to the macula, and it then presents a striking picture to the ophthalmoscope. The larger vessels of the choroid stroma pass in a sinuous manner

across the eye-ground, bringing out into distinct relief, the pigmented connective-tissue cells of the choroid proper, which lie between them (consult Fig. 104, page 354). Such appearances are seen in myopia; in "stretching eyes," when hypermetropic refraction is diminishing or passing into myopic refraction; in glaucoma; and sometimes is associated with retinal conditions, like pigmentary degeneration. The atrophy in this case is superficial, and of itself does not disturb vision.

Treatment.—An eye thus affected should be put at rest, its refractive error corrected under the use of atropine or similar mydriatic, and the patient be given an alterative. If this is an associated symptom in a glaucomatous eye, or one with pigmentary retinitis, the present directions do not apply.

Deep Choroiditis—(1) *Diffuse Exudate Choroiditis.*—Instead of the normal red of the eye-ground the ophthalmoscope reveals white or yellowish-white plaques, sometimes separated by partly normal choroid, more often running into one another until a huge expanse of exposed sclera is seen throughout the fundus.

Fig. 101.



Diffuse exudative choroiditis, with choroido-retinitis (E. v. Jaeger).

The white patches appear speckled because numerous pigment masses of black color are collected upon them, irregular in form,

sometimes gathered in lumps, sometimes assuming variously shaped groups. They lie beneath the retinal vessels for the most part, although usually pigment will be found collected upon these retinal vessels showing the participation of the retina in the process (*choroido-retinitis*). (Fig. 101.) In other patches the atrophy has not been sufficient to expose the glistening white sclera, and here will be found the appearances described in superficial choroiditis, namely band-like, orange-yellow, or light red vessels, freely anastomosing with each other, and, between them, the pigmented epithelium. In still other spots, it may be, that a yellowish exudate is evident, which is the earlier stage of what afterwards becomes an absorbed spot, surrounded and partly covered by black pigment heaping.

In cases like this all the stages from yellowish extravasation to complete atrophy are visible.

(2) *Disseminated Choroiditis.*—Another form, which may be looked upon, according to a classification adopted by some authors, as the circumscribed variety of the type just described, is that which is known as *disseminated choroiditis.*

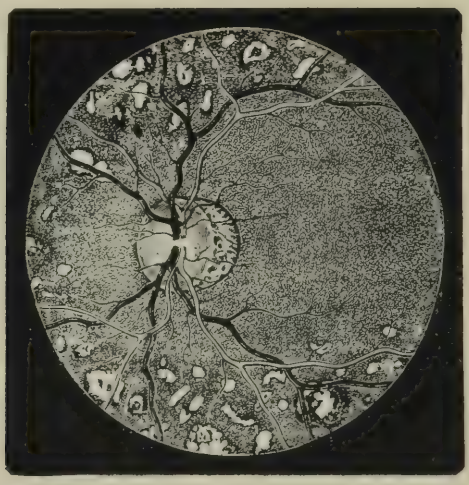
In this type, usually beginning in the periphery, but gradually approaching the centre of the eye-ground, numerous round or oval spots surrounded by black margins are found. The white centre of the spot is the exposed sclera; the black margin, the altered pigment. Again, instead of a white centre there may be a single black mass, in its turn encircled by a yellowish ring. A very characteristic appearance arises when the spots assume a punched-out look, as if a sharp instrument had cut out the tissue down to the sclera, the margins of the incision being bordered with pigment.

These spots of disseminated choroiditis vary greatly in number. There may be only one or two, or the eye-ground may be dotted over with them. Between the spots the choroid tissue is comparatively healthy. Like the diffuse variety, the earlier stages of such spots consist in small, yellowish exudations, which gradually absorb, producing the atrophic marks which have just been described. The relation of the retinal vessels to the pigment epithelium is the same as in the previous variety. (Fig. 102.)

Vitreous opacities are often present, either faint and floating,

or large, string-like, and membranous. There may also be cataract at the posterior pole of the lens.

Fig. 102.



Disseminated choroiditis (Wecker). The illustration also shows an atrophic crescent (posterior-staphlyoma) at the outer side of the nerve-head.

The optic nerve becomes affected in the later stages of this disease and undergoes a species of atrophy to which the name of *choroiditic atrophy* has been applied. The edges of the disc are slightly hazy, the color a reddish-yellow, and there is contraction of the retinal vessels.

Causes.—The cause of deep choroiditis, either diffuse or circumscribed, is due to acquired syphilis in a great number of cases, and appears from six months to two years after the initial infection. Sometimes it is postponed to a much later period. Opacities in the vitreous increase the probability of syphilis, and although certain types have been looked upon as especially characteristic of this disease, it is not safe to attempt to make a diagnosis of syphilis, simply by the appearances of any of the varieties of choroiditis. Disseminated choroiditis, choroido-retinitis, and secondary pigment-degeneration of the retina are seen in children, the subjects of hereditary syphilis. Choroiditis due to acquired syphilis usually affects both eyes.

A disseminated choroiditis affecting both eyes, is occasionally encountered as a family disease independently of syphilis, and associated with disorders of the central nervous system. (Hutchinson.)

A choroiditis quite undistinguishable from the forms described, may result from an injury. Patches of choroiditis are found in the eyes of children born with cataract. Choroiditis is also attributed to disturbances of nutrition, anæmia, chlorosis, and scrofula, and sometimes no cause can be found.

Treatment.—This depends upon the cause. If it is syphilitic and the patient is robust, inunctions of mercurial ointment should be practised, to be followed by iodide of potash. Later, a prolonged course of the bichloride of mercury with the tincture of iron is advisable. Anæmia and scrofula require the usual treatment.

All close work must be forbidden; the eyes should be protected with dark glasses.

Prognosis.—The prognosis is always a grave one; it is best in the syphilitic cases. If there should be much opacity in the vitreous, pilocarpine sweats may be tried; in old cases, strychnia and the galvanic current have been advised.

Central Choroiditis is the name applied to choroiditis confined to the region of the macula.

There may be an irregular patch of exudation, semi- or completely atrophic, and bounded by pigment. This is recognized objectively by the ophthalmoscope, and subjectively by scotoma in the field of vision marking this region.

Again, the macula may be occupied or surrounded by a large, white patch, the rest of the eye-ground being normal. This type is sometimes known as *senile areolar atrophy of the choroid* (Fig. 103). The area may be entirely circular and the deep vessels exposed, or they may be atrophied and converted into white lines.

In the same region there is observed another variety of the disease, first described by Tay and Hutchinson as central *senile guttate choroiditis*, marked by the appearance of numerous, white, glistening dots, somewhat resembling the earlier stages of albuminuric retinitis (Nettleship), and always symmetrical, though

sometimes an interval of time elapses before the implication of the second eye. The white spots are due to colloid degeneration and calcareous formations in the choroid, and are associated with secondary involvement of the retina. Usually there is contraction of the field of vision and negative scotoma.

Fig. 103.



Central choroiditis (Wecker and Jaeger). The circular character of the patch and the exposure and partial atrophy of the deep vessels are well shown.

It is important, if possible, to recognize all forms of central choroiditis before a cataract operation is performed. This may be suspected if there is imperfect central fixation for light, but really can be positively determined only when the cataract is still incipient and the ophthalmoscopic examination is possible.

Causes.—Central choroiditis of inflammatory type may be caused by syphilis and also by blows upon the eye. Chronic atrophic choroiditis in this region is seen in myopia, and Gould has described macular choroiditis as the result of uncorrected ametropia and insufficiency of the internal recti muscles, even in non-stretching eyes ("*ametropic choroiditis*"). Senile changes account for senile central choroiditis and the guttate variety.

Treatment.—In the syphilitic variety the usual remedies are indicated. In types connected with refractive error, the best possible correction should be given and absolute eye-rest

enjoined. In the senile varieties, both the ordinary and the guttate types, treatment appears to have no influence.

Unclassified Forms of Choroiditis.—Besides the diseases of the choroid which have been described, others appear which cannot be definitely classified:

Large patches of atrophy not located in special portions of the choroid, resulting probably from the absorption of former hemorrhages, or, perhaps, tuberculous areas; hemorrhagic choroiditis occurring, as pointed out by Hutchinson, especially in young men, and resulting in numerous spots of atrophy which are not readily distinguished from those of the syphilitic variety; yellowish or other spots of choroidal disease, which have been attributed to the action of intense light or the glare of heat; slight macular changes in the form of small yellowish or maroon-colored spots, sometimes with a few scattered pigment granules in the immediate vicinity of the fovea, which do not affect vision and are unnoted by the patient. These have been attributed by some authors to the influence of abnormal refraction, but are sometimes seen in association with transient albuminuria, and probably represent small spots of degeneration, inclosed by a single capillary loop which has become impervious.

Myopic Choroiditis.—Atrophy of the choroid, commonly of a local character, occurs in severe, or, as it has sometimes been called, malignant myopia, and is observed either in connection with, or surrounding, the nerve head. It is caused by the elongation which occurs at the posterior pole of the eye, and receives the name *posterior staphyloma*.

The term *sclerotico-choroiditis posterior* is also applied to this variety of choroidal change, just as anterior sclerotico-choroiditis is the name given to the inflammatory affection, which attacks circumscribed portions of the anterior part of the choroid, with corresponding portions of the sclerotic, and which, in aggravated instances, may give rise to staphylomatous bulging, and gradual loss of vision by opacity of the vitreous and cornea (see page 304).

Semi-atrophic and atrophic crescents also appear at the outer margin of the disc in astigmatic eyes, and in eyes undergoing change owing to the distension of their coats from too close work,

aggravated by imperfectly or improperly corrected errors of refraction.

In the macular region in myopia, there may be very decided semi-atrophic or atrophic patches having the general characteristics of the spots already described, and greatly interfering with vision. The process begins in the form of small rents which gradually coalesce into an atrophic patch. In like manner, this area may be involved by a hemorrhage in progressive myopia, which after absorption leaves impaired vision, owing to the damage to the overlying retina. The vessels of the choroid are exposed by maceration and absorption of the pigment epithelium causing the appearance described under superficial choroiditis. (Fig. 104.)

Fig. 104.



Myopic choroiditis (Wecker and Fuchs). The cut illustrates posterior staphyloma—the white area surrounding the nerve; atrophic choroiditis in the macula—the disseminated white patches in the central part; and general exposure of the choroidal vessels by absorption of the pigment epithelium.

Suppurative Choroiditis and Irido-Choroiditis.—Acute iritis occasionally becomes complicated with inflammation of the choroid (page 315), and a chronic type of irido-choroiditis, which tends to loss of vision and shrinking of the eyeball has been described (page 325).

The present disease, however, is distinguished by a suppurative process between the retina and choroid, which extends into the vitreous, and spreads into the entire uveal tract.

Symptoms.—There are œdema of the lids, chemosis of the conjunctiva, haziness of the cornea, inflammation of the iris and ciliary body, and, it may be, hypopyon. If there is sufficient transparency of the media, the purulent mass may be seen in the vitreous, giving the appearance of a yellowish reflection, when viewed by transmitted light. At first the tension is raised and the anterior chamber is shallow.

In addition to these objective symptoms, there are severe brow pain, tenderness of the globe, loss of vision, and constitutional symptoms, like chill and fever.

The ultimate result depends upon whether the disease remains localized in the uveal tract and vitreous, or spreads to all of the tissues of the eyeball. In the former case the inflammatory symptoms subside, the pain lessens, the intraocular tension is lowered, and the eyeball gradually shrinks.

In the latter case the inflammation spreads, the œdema of the lids and chemosis of the conjunctiva are intense, the pain severe, and the constitutional symptoms—fever, chills, nausea and vomiting—are very marked. The inflammation involves Tenon's capsule, and causes protrusion of the globe, which is pressed against the swollen lids until these can scarcely be separated on account of the swelling and œdema. Finally, rupture of the sclera or sloughing of the cornea occurs, the purulent matter finds a vent, the pain subsides, and in about six weeks the ball is soft, sightless, shrunken and free from pain. This second outcome of purulent choroiditis is known as *panophthalmitis*, and the ultimate result as *phthisis bulbi*.

Causes.—Purulent choroiditis is caused by the introduction of pathogenic microbes in the same manner as in purulent cyclitis. It is hence seen as the result of perforating wounds; septic cataract extraction; and sloughing ulcers of the cornea.

Purulent choroiditis is also caused by embolism from a microbic area, *e. g.*, in pyæmia, especially in puerperal sepsis, septicæmia, and endocarditis. A common cause is cerebro-spinal meningitis, especially in children, and it has also occurred in wasting diseases,

in dysentry, measles, and especially in smallpox with corneal complication. Inflammation of the umbilical vein, and thrombosis of the orbital veins are known to cause the disease.

Prognosis.—This is bad, and almost invariably blindness with shrunken eyeball is the result of the inflammation. A few cases of recovery from suppurative irido-choroiditis following cerebro-spinal meningitis have been recorded.

Treatment.—In the early stages antiphlogistic treatment may be of service in robust cases—bloodletting from the temple, a sedative fever mixture, with sufficient morphia to relieve pain, and locally, frequently changed ice compresses. In later stages warm fomentations are better, a square of lint being soaked in heated bichloride solution; and internally, opium and quinine in full doses. If there is much pain before spontaneous rupture has occurred, a free incision into the sclerotic will bring relief.

Surgeons differ in regard to the advisability of enucleating the globe during the acute stages of panophthalmitis, some operators declining to perform excision under such circumstances, in the belief that meningitis is liable to follow, while others do not recognize such a danger, and do not hesitate to operate.

Under these circumstances evisceration has been recommended because the channels leading to the brain membranes are not opened and micrococci are less liable to enter. But even after evisceration there may be a great accumulation of inflammatory products behind the scleral cup, and to these a vent must be given; hence Noyes advises that while certain cases of panophthalmitis should be treated to the termination of the suppurative process without operation, in the majority of instances, deep incisions, with or without enucleation, are the best method of relief, even when the symptoms of meningitis have appeared.

Tumors of the Choroid.—The most frequent neoplasm of the uveal tract, and, for the present purposes of description, of the choroid, is *sarcoma*. Most commonly it appears as a pigmented growth (*melano-sarcoma*); more rarely without pigment (*leuco-sarcoma*).

Sarcoma of the choroid, in the majority of cases, occurs between the ages of thirty-five and fifty years; it is rare under the twentieth year. Men are more frequently affected than

women, and the left eye is more apt to be affected than its fellow. The growth usually is circumscribed, in which case it may or may not have a pedicle. Rarely, there is a diffuse sarcomatous infiltration of the choroid.

Sarcoma may be either round or spindle-celled, and the ordinary degenerations to which this form of tumor is subject are seen in these choroidal growths. Sarcoma of the choroid is almost invariably a primary growth ; the choroid coat being rarely affected by a metastasis occurring from a tumor in some other portion of the body. The tumor arises from the layer of the larger vessels, and its most usual situation is near the posterior pole of the eye, at the outer side of the optic disc.

The life history of a sarcoma of the choroid has been divided by systematic writers into four periods: The first, the quiet period ; the second, the inflammatory period ; the third, the extra-ocular period, or that stage when the growth bursts through the scleral boundary ; and fourth, the period of metastasis.

In the *first stage* the diagnosis is difficult, as the disease resembles a detachment of the retina, this membrane being pushed forward by the underlying elevation, the whole being surrounded by a serous effusion. By carefully looking through this retinal covering the brownish mass beneath may be recognized, covered by irregular choroidal vessels, a point, however, not always ascertainable, if the original growth is of the non-pigmented variety. If the growth is situated far forward, it is sometimes possible to examine it by means of oblique illumination through a dilated pupil. There is a corresponding defect in the field of vision, and the sight of the affected eye is diminished in accordance with the situation of the tumor. Should this be peripheral, the central vision at this stage may not be seriously affected.

In the next period of the history of this growth, or the *inflammatory* or *glaucomatous stage*, symptoms of increased tension arise: pain in the brow, anæsthesia of the cornea, shallowing of the anterior chamber, and dilatation and tortuosity of the perforating episcleral vessels. Ophthalmoscopic examination is no longer possible, the localized detachment of the retina becomes general by increased serous effusion, the lens may become cataractous, and

a severe irido-cyclitis may be set up, which in its turn may be the cause of a sympathetic irritation of the fellow-eye.

As the growth continues, the sclera becomes ruptured and the surrounding tissues are involved (*fungus-stage, or stage of episcleral tumors*). It may pass backward into the brain, or secondarily affect the optic nerve, but more commonly the last, or *metastatic stage* (*stage of generalization*) develops, when distant organs are attacked by growths of similar histological character, the liver far more frequently than other organs, but also the spleen, intestines, and even the lungs. Metastasis to the liver need not necessarily be delayed until the tumor has burst, at least not visibly, through the scleral boundary. One of the most extensive cases of secondary sarcoma of the liver which has come under the writer's notice, was in connection with a small sarcoma of the choroid, in which there was no external manifestation, but in which a few fragments in the orbital tissues appeared to be of suspicious nature after the removal of the eye.

Diagnosis.—It is necessary to differentiate the sarcoma of the choroid from glioma of the retina. To this reference will be made in a future section.

In the early stages choroidal sarcoma may be mistaken for idiopathic detachment of the retina. In the former, the defect in the field of vision is more sharply circumscribed, the central vision less decidedly affected, and the ophthalmoscope reveals no tremulousness of the overlying retina. Sarcoma may also be mistaken for a solitary tubercle of the choroid.

In the stage of increased pressure, the disease is to be distinguished from glaucoma by observing the suddenness of the onset of inflammatory symptoms—in the latter disease without antecedent history of poor vision—and the fact that in the glaucomatous eye, there are remissions in the acute symptoms, and that the tension is somewhat amenable to the myotics.

Prognosis.—The prognosis in this form of neoplasm is very bad. It is usually stated that death will occur within five years after the appearance of the original growth, provided no operation has been undertaken in the earlier stages. The published statistics show that the duration of the first, or quiescent period, is from one and one-half to two years. If there is no recurrence

within four years, after removal of the eye, this complication becomes unlikely, although exceptions to this rule have occurred, and recurrence has been noted even after seven years.

If the operation has been delayed, there may be local recurrence in spite of it, and, what is still more serious, metastasis to a distant organ.

Treatment.—From what has been said, it is evident that the only treatment is enucleation, and this at as early a stage as possible. It may be necessary to remove the entire contents of the orbit.

Rare forms of tumor of the choroid are the following: *Cavernous angioma*, *glandular tumor*, or *adenoma*, *enchondroma*, and a variety of sarcoma known under the name of *sarcoma-carcinomatosum*. The writer has examined one such case microscopically.

Carcinoma of the Choroid is a very rare disease (about twelve cases being on record) and in all instances thus far reported, has been metastatic after carcinoma of the breast.

Tubercle of the Choroid.—Tubercles appear in the choroid as yellowish-white spots, varying in size from one to one and one-half millimetres, occasionally larger, and usually, though not necessarily, associated with similar growths in the meninges. Repeated examination is required for their detection, and even then they may escape observation, owing to their diminutive size ("*choroidal dust*"). They have been frequently found in post-mortem examinations.

Tubercles known as miliary tubercles, are distinguished chiefly by their color, which has been described as of a dull, yellowish-white in the centre, encircled by an ill-defined rose-colored area. (Horner.) There are no pigmentary changes in the immediate neighborhood, as would be the case in most other forms of limited choroidal disease. They are situated usually near the optic disc, or in the macular region, and vary in number from three to six, or many more.

Instead of the miliary growth, a single large tubercular tumor may appear and progress, producing the same destructive changes that a sarcoma would originate, from which, indeed, it is very

difficult to distinguish it. Such a growth may be associated with a similar one in the brain.[1]

Treatment.—Miliary tubercles of the choroid do not require any treatment directed to the eye itself, the vision of which may not be seriously affected. If a single large choroidal tumor were recognized, and the patient's general condition permitted it, enucleation to avert general tuberculosis is recommended.

Injuries of the Choroid— *Wounds of the Choroid.*—Necessarily in a perforating wound of the sclera, the choroid is also lacerated or incised, and no description other than that already given in this connection is required.

Foreign Bodies in the Choroid.—A penetrating foreign body may lodge in the choroid, and then the treatment described on page 306 is applicable.

Rupture of the Choroid.—The most important injury to which the choroid is subject, and which follows a blow upon the eye, is rupture. This generally manifests itself in a sickle-shaped crescent, commonly on the temporal side of the disc, rarely on the nasal side, and very seldom extends in a horizontal direction. The rupture may be single or multiple, and sometimes is composed of several branches. The immediate effect of the blow is a hemorrhage preventing distinct observation. When this has disappeared, the fissure is evident to the ophthalmoscope as a yellowish-white stripe bordered with some disturbed pigment. (Fig. 105.)

The ruptures run concentrically with the papilla. They may be either complete or incomplete, and may, or may not, be associated with breakage of the overlying retina. In rupture confined to the choroid, the retinal vessels pass over it. If the retina has also given way there is apt to be more hemorrhage than without such accident, and no retinal vessels are observed crossing the choroidal separation.

[1] Under the name of *chronic tubercular choroiditis*, a disease has been described which must be of very rare occurrence, characterized by optic neuritis, hemorrhages, and a diffuse, yellowish-white discoloration occupying a considerable area of the eye-ground. It is limited to one eye and is seen in association with tubercular disease of the brain likely to terminate in a fatal issue. (Berry.)

The ultimate result to vision depends upon the size and situation of the rupture. At first there is very considerable loss of vision, partly due to effusion, and partly to injury of the iris, sometimes associated with blood in the anterior chamber. This

Fig. 105.



Rupture of the choroid. (Wecker).

slowly clears away, and very good vision may result, provided the change in the eye-ground has not been extensive. A deterioration of vision may occur a long time after such an injury, owing to secondary changes in the optic nerve.

Treatment.—The pupil should be dilated with atropine; if there is much pain, a leech or two should be applied to the temple, a pressure bandage adjusted, and the patient put to bed. These measures suffice to encourage the absorption both of the blood and of the serous effusion.

Hemorrhage into the Choroid.—In the section on unclassified forms of choroidal disease, variously-shaped hemorrhages which appear in this membrane, and which by absorption give rise to atrophic spots, have been described. In like manner there may be hemorrhage from the choroid, the result of a blow. A choroidal hemorrhage may be distinguished from one situated in the retina by noticing the more diffuse character of the extravasation and the fact that the retinal vessels pass over it, but the diagnosis is difficult.

Detachment of the Choroid.—This must be exceedingly rare, and observers of vast experience have stated that they have never seen a case. The probable cause of detachment would be by blood, serum, or a new growth. Cases following cataract extraction have been reported.

Ossification of the Choroid.—This is occasionally found in eyes long blind and shrunken from destructive irido-choroiditis. The formation of bone occurs in the inflammatory tissue, and may be recognized by palpation in the form of an irregular plate, spicule, or complete shell. Calcareous degeneration is common in eyes of this character. The eyeball should be enucleated.

CHAPTER XII.

GLAUCOMA.

GLAUCOMA[1] is the name applied to several varieties of a disease of which increased intraocular tension is the most characteristic sign.

VARIETIES OF GLAUCOMA.—(1) *Primary glaucoma*, or that form which arises without antecedent disease of the eye, and (2) *Secondary glaucoma*, or that form which occurs as the sequel of a pre-existing ocular disease, often an inflammation of the uveal tract.

Primary glaucoma is *acute*, *subacute*, or *chronic*, and is further subdivided into *inflammatory* or *congestive*, and *simple*, or *non-inflammatory*, *non-congestive* glaucoma.

SYMPTOMS.—The following is a syllabus of the symptoms common to the disease glaucoma, though not constantly present in each variety :—

(1) *Rise in intraocular tension*, or increased hardness of the eyeball, varying from T ? ("stiffened sclera") to T + 3 ("stony hardness"). In the former a positive rise of tension may be doubtful, the sclera simply presenting more than the usual resistance to the palpating finger ; in the latter, firm pressure fails to produce impression. Intermediate degrees are T + 1 and T + 2.

This increased hardness of the eyeball may be measured by an instrument known as a *tonometer*, but in practice is estimated by palpating the globe with the finger tips in the manner described on page 90.

[1] The name is derived from the Greek word γλαῦκος meaning *sea-green*, because at one time this disease was known only by one of the signs of its final stages, viz., a greenish-yellow discoloration seen through the dilated pupil. According to Snellen, the characteristic symptom of glaucoma—increased hardness of the globe—was first properly recognized by Mackenzie in 1830.

(2) *Change in the Size and Shape of the Pupil and Mobility of the Iris.*—The pupil may be round, oval, or egg-shaped, semi-dilated, or expanded to its fullest limit; the iris sluggish in movement, or entirely inactive. In simple glaucoma abnormal pupillary symptoms may be absent.

The pupillary space sometimes transmits a greenish reflex (hence the name given by the older writers) from the surface of the lens. The dilatation of the pupil is explained by paresis of the ciliary nerves, or by constriction of the vessels of the iris.

(3) *Loss of the Transparency of the Cornea.*—The cornea somewhat resembles the appearance of glass, the surface of which has been dulled by being breathed upon. This haziness is marked in the congestive types of glaucoma, but is absent or only slightly present in the simple varieties. If the cornea is carefully examined, the cloudiness will be found more decided in the centre, and will resolve itself into very numerous closely-aggregated points, the whole presenting a stippled or "needle-stuck" appearance. Iritis and irido-choroiditis may produce a similar appearance (Schweigger). The condition is caused by œdema of the cornea.

(4) *Change in the Depth of the Anterior Chamber.*—This symptom varies from an almost imperceptible shallowing to a complete obliteration. While it is not customary to divide the various grades of narrowing of the anterior chamber into degrees, as has been done with tension, such a division might include doubtful loss of depth, moderate loss, great narrowing, and complete obliteration. During the course of glaucoma the lens-system and peripheral portion of the iris are pushed forward, and this causes the depreciation in the depth of the anterior chamber.

(5) *Change in the Normal Appearance of the Iris and Turbidity of the Aqueous and Vitreous.*—The same œdema which affects the cornea, may also cause loss in the characteristic markings of the iris, so that its pattern becomes indistinct, especially in congestive forms of glaucoma. The veins of the iris may be dilated and tortuous. Opacities in the media also are liable to form, and the lens itself may become cataractous.

(6) *Alterations in the Conjunctival and Episcleral Vessels.*—In acute glaucoma there are usually general hyperæmia and often œdema of the conjunctiva, but in chronic inflammatory, and even in simple glaucoma, there are marked enlargement and tortuosity of the episcleral venous branches. (System II., page 61.)

(7) *The Excavation of the Nerve-head and the Surrounding Yellowish "Halo," or "Glaucomatous Ring."*—Under the influence of the increased intraocular pressure, the most impressionable portion of the eye—the intraocular end of the optic nerve—gives way, and the glaucomatous cup is produced.

The cupping of the optic disc is seen with the ophthalmoscope, and its depth is measured according to the directions given on page 120. It is also recognized by employing the parallax test with the indirect method as follows: The optic nerve is found in the usual manner by the inverted image, and the object lens moved from side to side. The entire eye-ground apparently moves with the motions of the lens, and the bottom of the excavation also seems to move in the same direction, but at a much slower rate. The contrast in the rate of the two movements is in a direct ratio with the depth of the excavation.

The cup varies from one beginning to be pathological to a fully formed excavation. In the latter instance the excavation is complete to the scleral margin, and its edges are abrupt; the vessels are crowded to the nasal side, bend sharply over the margin, and are lost to view behind the border of the cup, reappearing in fainter color at its bottom.

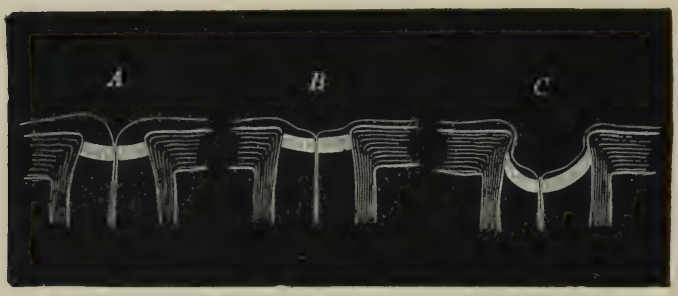
The papilla is encircled by a yellowish ring due to atrophy of the surrounding choroid.

It is important to distinguish between a large physiological cup, an excavation due to atrophy of the optic nerve, and the glaucomatous cup. A physiological excavation is partial and formed in a normally tinted nerve-head; an atrophic excavation is complete, shallow, and formed in a nerve-head of abnormal whiteness owing to its loss of capillarity; and a glaucomatous excavation is complete, deep, and often of greenish hue. (Consult fig. 106.)

These points apply to typical forms of each variety of excavation. Sometimes it is a matter of considerable difficulty to

decide between them, especially between an atrophic and a glaucomatous excavation when the latter is shallow; or between a physiological excavation and glaucoma, when the former is associated with primary optic atrophy (Schweigger). A diagnosis must then be based upon an examination of the other symptoms, particularly the field of vision.

Fig. 106.



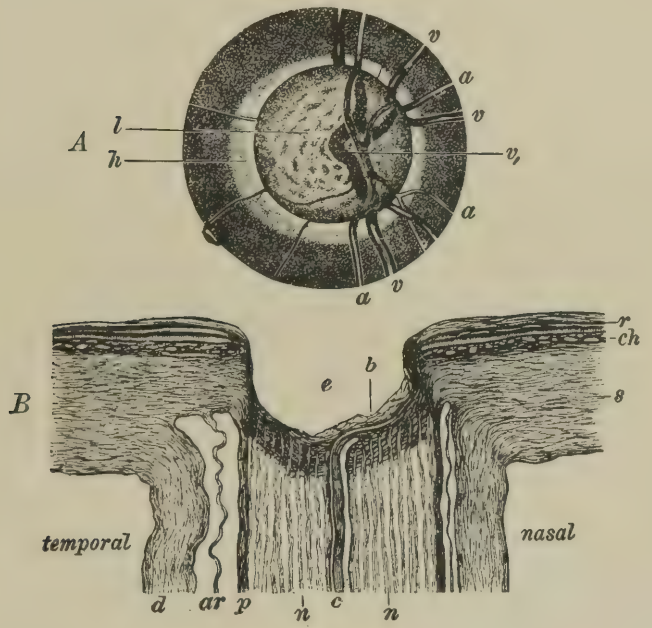
Varieties of excavations in the nerve-head. *A*. Physiological excavation—partial, funnel-shaped, lamina cribrosa normal. *B*. Atrophic excavation—saucer-shaped, total, lamina normal. *C*. Glaucomatous excavation—total, ampulliform, lamina pressed backward (Fuchs).

(8) *Vessel-Pulsation on the Surface of the Disc.*—(a) *The veins.*—There is often marked venous pulse, especially at the dark knuckles of the veins as they bend over the margin of the excavation, but this is a common ophthalmoscopic appearance in healthy eyes (page 110), and hence cannot be utilized as a diagnostic symptom.

(b) *The arteries.*—Pulsation of the arteries is a rare appearance except in cases of aortic regurgitation, and therefore may be regarded as an important indication of increased intraocular tension, in high degrees of which it is a striking symptom, the arterial trunks on the surfaces of the disc showing rapid alternate filling and collapse. The cause of spontaneous arterial pulsation resides in the resistance to passage of the blood through the vessels, a resistance which in its turn depends partly upon increased tension, and partly upon spasmodic contraction of the vessels themselves. In cases of glaucoma in which this pulse is

not spontaneously visible it may be induced by slight pressure upon the globe.

Fig. 107.



Glaucomatous excavation of the optic papilla. *A*, Ophthalmoscopic picture of the papilla. *B*. Vertical section through the nerve-head (figure and description after Fuchs).

In the upper figure, *A*, the papilla is seen to be bordered by a sharp, overhanging margin, at which the arteries *a* and the veins *v* appear to terminate in rounded ends. Their continuation to the bottom of the excavation is somewhat displaced toward the side. At the outer half of the excavation the stippling of the lamina *l* is visible. The papilla is bordered by a white zone *h*—the glaucomatous halo.

In the lower figure, *B*, the nerve-head exhibits a deep excavation, *e*, upon the floor of which a few remains of nerve fibres, *b*, are noticeable. The central vessels, *c*, proceed upward to the retina on the nasal side of the excavation; *ch* indicates the choroid, *s* the sclera. The nerve trunk has lost in volume owing to atrophy of its fibres, *n*. On account of this the spaces between the sheaths of the optic nerve have widened, *p*, *ar*, and *d*.

The student will more readily understand the objective symptoms of glaucoma described in the preceding paragraphs by examining figure 107.

In addition to the *objective* signs of glaucoma just described, certain *subjective* symptoms are more or less constantly present.

1. *Pain.*—This, like the disease itself, may be acute, subacute and chronic, somewhat, though not by any means exactly, corresponding to the types of glaucoma thus designated.

In acute attacks the pain is a severe neuralgia of the trigeminal distribution, and often, in violent congestive cases, an intense agony associated with great depression, pallor of the countenance, nausea and vomiting.

In subacute attacks there is a less marked similarly located pain.

In chronic cases there may be only a general feeling of discomfort, a sense of fulness, occasional shoots of neuralgia, or attacks described by the patient as headache.

2. *Alteration in the Sensibility of the Cornea.*—Anæsthesia of the cornea, when present, varies from a slight depreciation in its sensitiveness to an entire loss of sensation, as complete as that produced by cocaine. A useful test is to take a wisp of cotton, twisted to a point, and stroke the surface of the cornea, comparing this with the unaffected eye, care being taken not to come in contact with the eyelid. Sometimes the anæsthesia is not uniform over the surface of the cornea, but exists in spots or segments. It is due to the œdema of the structure, which presses upon the filaments of the corneal nerves.

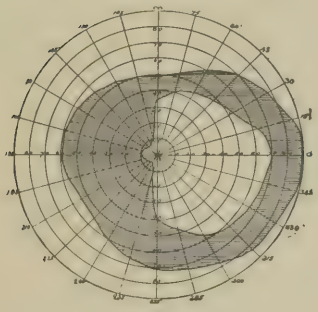
3. *Alterations in Central Visual Acuity.*—This symptom varies considerably, and in chronic cases excellent sharpness of sight may be preserved for a long time. It is important to remember this, because it is not safe to depend upon central vision as a guide of the rate of progress of a chronic glaucoma. In each attack of subacute glaucoma the vision quickly fails, and gradually is recovered as the attack passes away. Each recurrence leaves a more permanent impression. In acute glaucoma, a characteristic symptom is the sudden loss of vision, which in a few hours may be reduced to a light perception, and in certain malignant types rapidly becomes absolute.

4. *Diminution of the Refractive Power of the Eye and of the Amplitude of Accommodation.*—The former depends upon the change in the shape of the cornea, and the latter upon the effect

of pressure upon the ciliary nerves. A very important event in chronic glaucoma is the changing of an astigmatism "according to the rule" to one "contrary to the rule," while the diminished power of accommodation is evidenced by the desire of patients to change their reading glasses to such as are stronger than the degree of refractive error or age of life would warrant.

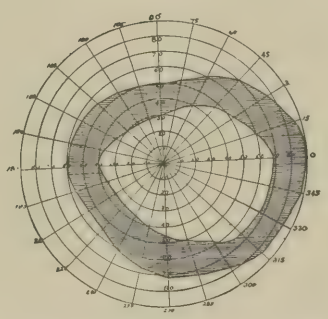
5. *Alteration in Peripheral Vision, or the Field of Vision.*—A careful map of the field of vision in glaucoma is indispensable, and the restrictions present themselves in several forms: (*a*) The most usual and typical variety is partial or complete loss of the nasal field; (*b*) concentric restriction of the entire field; (*c*) restriction so constituted that the remaining field assumes an oval or trowel shape; (*d*) sectional defects, commonly including the upper portion; (*e*) loss of the entire field except a patch on the temporal side; (*f*) the formation of dark areas or scotomata. (Figs. 108, 109, 110, 111, 112.)

FIG. 108.



Field of vision of right eye in a case of subacute glaucoma. Loss of the nasal half and concentric restriction of the preserved field.

FIG. 109.

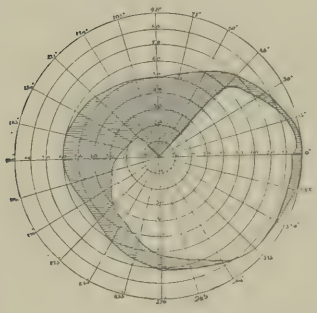


Field of vision of right eye in a case of chronic glaucoma, showing concentric restriction of the field.

The contraction of the color fields is usually proportionate to that of the form field. Under the influence of operative measures or myotics very decided changes in the visual field may take place. The change in peripheral vision is a more accurate index of the rate of progress in glaucoma than central vision, but it is not a safe one.

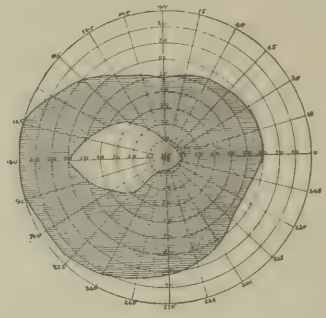
The tendency of the visual field is to contract progressively as the disease advances, and finally all portions are obliterated ex-

Fig. 110.



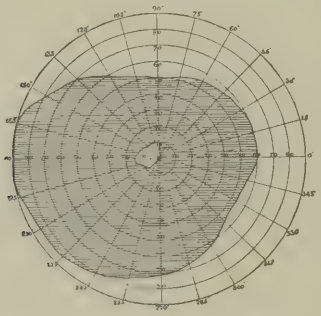
Field of vision in right eye in case of chronic glaucoma, showing sectional defect (supero-nasal quadrant).

Fig. 111.



Field of vision of left eye in chronic glaucoma. Trowel-shaped patch preserved chiefly on the temporal side.

Fig. 112.



From the same case as fig. 111, six months later, only a small patch of preserved field on the temporal side.

cept a small part upon the temporal side, which also disappears in the ultimate blindness, if the disease is unchecked. (Consult fig. 112.)

6. *Iridescent Vision.*—This consists in variously-hued borders surrounding artificial lights, which thus become invested with a colored halo ("halo-vision"), the red circle being the outermost.

This phenomenon has been attributed to various causes depending upon physiological or physical effects. Experimental

evidence tends to support the opinion that the cause resides in the cornea, and depends on alterations in its epithelium, the result of exaggerated pressure.[1]

Subjective sensations of light are experienced at times by totally blind glaucomatous patients. The explanation is probably a mechanical one, and the sensation depends upon a dragging on the retina. In one case noted by the writer, both eyes being blind from glaucoma, the patient declared "all things seemed to be a sea of red fire."

The clinical varieties of glaucoma may now be described.

1. **Acute Glaucoma** (*Inflammatory or Congestive glaucoma*). —This type of the disease is suitably divided into two stages:—

(a) *Period of Incubation, or Prodromal Stage.*—This is characterized by sudden failure in the amplitude of accommodation, with a desire to resort to stronger reading glasses; temporary obscurations of vision, either dim vision or quite complete loss of sight, lasting for many minutes; attacks of foggy vision, all things apparently being invested with a haze; and the phenomena of colored halos around artificial lights. There may be some periorbital pain, the pupil is slightly dilated, and the cornea and the aqueous humor faintly turbid. The appearance of the optic nerve at this stage is not characteristic.

These prodromes bear some relation to emotional excitement and insomnia, and may occur when the head is congested, or after a full meal. After the eye regains its natural state, in a week or two the symptoms may reappear, again to subside and to be replaced by a fresh exacerbation, or a true "glaucomatous attack." The incipient period of glaucoma may last one or more years.

(b) *Period of Attack, or the "Glaucomatous Attack."*—This commonly begins during the latter part of the night, sometimes having been preceded by prodromes, but often without previous warning, and is characterized by violent pain in the head, so severe that it may induce nausea and vomiting. The face may be pallid, the extremities cold, or there may be flushing and

[1] According to Schweigger halo-vision occurs in mild attacks of iritis with slight deterioration of vision. It may also be caused by a layer of mucus overspreading the cornea during chronic conjunctivitis.

general fever. The eyelids are swollen, the conjunctiva injected and sometimes chemotic, the cornea steamy and anæsthetic, the pupil semidilated and motionless, the aqueous turbid, and the iris discolored. The tension rises very high, T + 2 or + 3, and vision is rapidly lost, often only light-perception remaining, and even this may be abolished. Usually the attack is bilateral; an interval between the two eyes may be from a few hours to weeks or months.

Gradually the symptoms pass away, with the exception of slight impairment in the mobility of the iris, some limitation of the field, and a little rise in tension. Blindness almost never occurs in the first onset. After some weeks or months these phenomena reappear. After a number of attacks, examination of the eye-ground during a remission (the fundus is not visible during an attack) may reveal the characteristic cupping, the halo, and the arterial pulse.

If the disease is unchecked, the eye passes into a *glaucomatous state*, with fixed and dilated pupil, discolored iris, greenish reflex from the lens, vitreous opacities, shallow anterior chamber, and hazy cornea. Vision is now gradually destroyed and the eye reaches the *state of absolute glaucoma*, when the ball is stony hard, the iris atrophic, the lens cataractous and pushed forward, the anterior chamber obliterated, the sclera discolored, the episcleral vessels coarsely injected, the cornea opaque, or perhaps ulcerated. Finally, there is disorganization of all the structures of the eyeball, and the sclera gives way with the formation of staphylomata, or the eyeball slowly atrophies as the result of choroiditis, change in the vitreous, and detachment of the retina. Acute glaucoma, instead of pursuing this course, occasionally passes into a chronic inflammatory type.

Glaucoma fulminans is the name applied to an aggravated, rare form of the acute disease, in which the symptoms may be fully developed in a few hours without a prodromal stage. There is no remission, and the destruction of vision is swift and permanent.

2. **Subacute Glaucoma.**—This type, like its predecessor, may or may not begin with certain prodromal signs. These, when present, become more pronounced and the eye gradually passes into a stage characterized by the constant presence of a series of

symptoms which are best described under the title *chronic inflammatory glaucoma.*

The cornea is deficient in transparency or positively steamy; there is marked tortuosity of the episcleral veins and some discoloration of the scleral tissue; the aqueous humor is turbid and the deeper media present opacities; ophthalmoscopic examination, when it is possible, reveals the cupped disc and pulsating vessels; the tension of the eye is raised; the pupil is semi-dilated, and the iris sometimes atrophic and sometimes not. Hence two types of chronic inflammatory glaucoma are described, one associated with degenerative changes in the iris, and one without such association.

The field of vision is contracted either upon the nasal side or in a quadrant form.

During the course of the disease acute or subacute attacks supervene; that is, there is sharp ciliary pain, increased steaminess of the cornea, increased injection of the eyeball, sinking of the vision, exaggeration of the tension, and marked anæsthesia of the cornea. The attack then passes away and in a few days or weeks repeats itself. Sometimes instead of a subacute attack of this character, an acute congestive exacerbation occurs, in all respects resembling the disease just described, and like it ending in absolute glaucoma, or in degeneration of the tissues of the eye. This disease may last from several months to a year.

3. **Chronic Glaucoma**, or **Non-inflammatory Glaucoma** (*usually known as Simple Chronic Glaucoma*).—This type of the disease is characterized by an absence of the signs of glaucoma in the anterior aspect of the eye, at least on ordinary inspection. By careful examination, slight steaminess of the cornea may sometimes be detected, with a little lack of transparency in the aqueous humor. So, too, there may be some undue tortuosity of the perforating branches of the episcleral plexus. In general terms, however, there is an absence of congestive symptoms and there is no pain. The tension of the eyeball is but slightly increased, and often it is difficult to decide whether it is increased at all. The anterior chamber is not much shallowed.

One or both eyes may be affected. If one eye is affected, then the pupil on that side is usually a little larger than its fellow; if

both eyes are affected, the one more advanced than the other, the pupil will be slightly larger on the side of the greater disease. The central vision is very good, and in the earlier stages of the disease, after the correction of any refractive error, may reach nearly the normal standard.

The media are clear, and the disease is detected with the ophthalmoscope, by observing the characteristic cup in the nerve-head, the halo surrounding it, and the spontaneous arterial pulse, or its ready development by slight pressure.

The field of vision gives important information. Usually the contraction is upon the nasal side, and this gradually increases and involves the fixing point. (Fig. 112.) The central color perception is good, and the contraction of the peripheral color perception corresponds with that of the form field.

Simple chronic glaucoma may assume a subacute or an acute nature like that already described, but it may also progress to blindness without very aggressive symptoms.

Causes.—Glaucoma is rare before the fortieth year. A few instances of primary glaucoma have occurred in children. On the whole, it is slightly more common in women than in men. Jews are peculiarly liable to this disease. Sometimes it is hereditary.

The refraction of a glaucomatous eye is usually hypermetropic, and, according to the belief of some authors, astigmatism against the rule predisposes to this disease.

Glaucomatous attacks may be excited in eyes predisposed to this disease by worry, insomnia, bronchitis, disturbances of the circulation on account of arterial sclerosis, and heart disease. It has been seen in association with gout and neuralgia of the fifth nerve. A number of instances are on record in which the instillation of atropine has been followed by an attack of glaucoma. The same is true of the other mydriatics. These facts should render the student cautious in the application of atropine to the eyes of elderly people.

Over-use of the eyes, especially with improperly corrected refractive error, has a distinct tendency, by causing ocular congestion, to bring on glaucoma in an eye predisposed to the disorder by changes in the ciliary region.

Should a patient between his fiftieth and sixtieth year desire to change his reading glass frequently, or use one stronger than is suited to his age or the condition of the refraction of his eye, there is reason to apprehend the onset of glaucoma. According to Priestley Smith, a large lens is a predisposing factor in the production of glaucoma. Those symptoms which have been described as prodromes are distinctive in themselves, and acquire an importance greater than any probable predisposition.

Mechanism.—Von Graefe explained the nature of the disease by assuming an inflammatory process—a serous choroiditis—originating in changes in the bloodvessels, typified by the acute types. Donders regarded irritation of the trigeminus as the factor which gave rise to a hypersecretion of fluid, just as stimulation of the chorda tympani induces excessive salivation, and believed the acute types were the results of increased tension induced by vaso-motor influence. These theories were no longer tenable after the discovery of the nutrition processes and the path of the circulation of fluids in the normal eye.

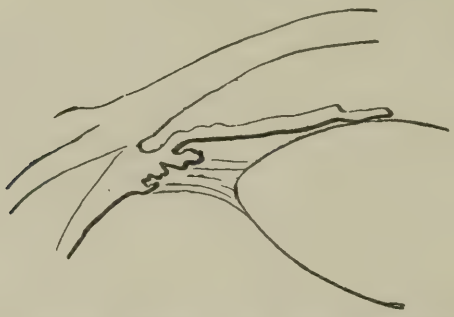
It has been demonstrated by Leber that the ciliary body is the chief secreting organ of the eye, and the current is thus described by Snellen :—

"The freshly secreted fluid stands in close osmotic relation to that which is contained within the thin membranes of the vitreous body. A slight excretion of fluid occurs at the back of the eye from the vitreous body into the lymph-spaces of Schwalbe in the optic nerve. The chief stream passes over the lens and through the pupil into the anterior chamber, traverses the latter to reach the angle formed by the junction of the iris and the cornea, passes through the meshes of the ligamentum pectinatum, and by diffusion and filtration is taken up into the plexus of veins known as Schlemm's canal. There is no direct connection between the anterior chamber and the lymph-spaces, which, according to Schwalbe, exist in Schlemm's canal. The influence of the nervous system on the pressure of the fluid is indirect. The pressure of the fluid regulates the outflow, so that when the afflux is increased, a compensatory increase of the efflux occurs."

Knies and Weber demonstrated that in glaucomatous eyes, with shallow anterior chambers, there is an adhesion of the iris-base to the periphery of the cornea, which prevents filtration at the angle of the anterior chamber, thus causing retention of

fluid. (Figs. 113, 114.) This discovery developed the theory which is supported by the largest number of advocates. Knies

Fig. 113.



Angle of the anterior chamber in the normal eye. (Birnbacher.)

Fig. 114.



Angle of the anterior chamber in glaucoma closed by adhesion of iris-base to the periphery of the cornea. (Birnbacher.)

believed that glaucoma originated in an adhesive inflammation of the iris-periphery, while Weber regarded this adhesion as secondary to the pressure induced by an abnormally swollen ciliary body. The fact that atropine does harm, by dilating the pupil, rolling back the iris, and partly closing the filtration angle, and that eserine does good, by contracting the pupil and drawing away the iris from this angle, indicates, as Snellen has pointed out, that the explanation of glaucoma is to be found, not in an increase of secretion, but in a disturbance of excretion.

According to Priestley Smith, obstruction of the circumlental space (*i. e.*, the space between the margin of the lens and the sur-

rounding structures) and consequent rise of pressure, may follow increased size of the lens due to advancing years, unusual smallness of the ciliary area in hypermetropia, or abnormal enlargement of the ciliary processes. This observer believes that hyper-secretion is sometimes concerned in the onset of glaucoma; that serosity of the fluids plays an important part in those forms which present a deep anterior chamber and wide filtration-angle; and that obstruction at this angle is part of the glaucomatous attack in the vast majority of cases.

Laqueur and other observers think that glaucoma depends upon obstruction of the intraocular lymphatics which find their way out with the vasa vorticosa, owing to rigidity of the sclerotic coat. Brailey describes a chronic inflammation of the ciliary processes and iris-periphery, with distension of the vessels, as the earliest lesion in glaucoma. Stilling believes that a hardening of the sclerotic surrounding the papilla, through which he thinks the waste fluids escape, leads to glaucoma.

The influence of strain upon the accommodation is explained by Snellen as follows: In the young eye, during accommodation for a near point, the diameter of the lens is reduced to about the same extent as that of the contracting ciliary muscle. The circumlental space remains about as wide as it was before, and the zonula remains tense as before. But the conditions are quite different in advanced life, when the elasticity of the lens is lost; the ciliary muscle contracts, but the form and size of the lens remain unchanged. The ciliary process is thereby pressed against the lens and the zonula slackened. Hence the necessity of correction of refractive errors as a preventive measure.[1]

Diagnosis.—It is of the utmost importance that glaucoma should be recognized, if possible, in its very incipiency. The

[1] A translation of the Dutch original of Snellen's article, "A Historical Essay on the Development of our Present Knowledge of Glaucoma," which has been quoted several times, is found in the Ophthalmic Review, Feb. 1891.

Inasmuch as the theories in regard to glaucoma do not explain its mechanism in all cases, it is possible that later investigations may prove that it really is a "nervous affection." Dr. Knapp, in clinical lectures, has dwelt upon the remarkable liability of the Jews to this disease as a significant fact in this connection. They are an essentially neurotic race, and prone to other nervous diseases.

most usual prodromal symptoms, are a frequent desire to change the reading glasses, periods of obscuration of vision, and the halos surrounding the lamp lights.

The glaucomatous attack itself has frequently been mistaken for a "cold in the eye," for iritis—when the disease has been aggravated by the instillation of atropine, which under all circumstances is contraindicated—for neuralgia, and for reflex ocular pain.

The condition of the pupil, the diminished depth of the anterior chamber, and, above all, the increased tension of the globe, are the symptoms which should prevent so fatal an error.

The differential diagnosis of simple chronic glaucoma and atrophy of the optic nerve has been referred to and presents considerable difficulty. The occasional absence of increased tension in the simple form of the disease, or at least its doubtful presence, removes an important diagnostic point. Help may be obtained by observing the color fields. In glaucoma these present a restriction corresponding with that of the form fields, while in atrophy the peripheral color vision, especially for red and green, is markedly deficient.

Examination of the light sense may be made. In glaucoma the "light minimum" is said to be deficient, but the "light difference" not far from normal; in pure optic atrophy there is imperfect ability to distinguish between different intensities of illumination ("light difference"). Practically, these examinations are difficult to make and the results are not always satisfactory.

It is an inexcusable error to confound the failing vision of chronic glaucoma with that of cataract, the greenish reflex of the lens, which may be seen in the pupillary space, being mistaken for an opacity of the lens. Eyes have been permitted to pass into blindness, and their possessors deluded with the hope that they were waiting for the ripening of a cataract which never existed. An ophthalmoscopic examination would settle the diagnosis at once.

Prognosis.—Glaucoma does not lead to spontaneous cure, but tends, if unchecked, to absolute blindness; hence the prognosis is unfavorable if proper treatment cannot be applied. Prognosis also depends upon the type of the disease and the stage of its

development. Other things being equal, uncomplicated acute cases furnish the most reasonable hope of complete cure. In chronic cases much depends upon the amount of degenerative change in the tissues, and the prognosis must be guided by the state of vision, the extent of the field, and the condition of the iris. The effect of treatment upon the progress of glaucoma is included in the following section :—

Treatment.—In practically all cases of glaucoma some form of operation—by preference iridectomy—is needed to check the disease.

It may happen, however, that an operation is not at once possible, and hence the myotics are temporarily indicated. In the prodromal stage eserine should be employed and will usually relieve the symptoms. In acute cases the same drug, in a strength of from one-half to two grains to the ounce, acts favorably, provided the pupil will contract under its influence. It acts more efficiently when combined with cocaine. Pilocarpine in twice this strength may be substituted. Myotics act by drawing the iris away from the filtration-angle, and, by contracting the pupil, cause widening of the spaces of Fontana and absorption of the fluid. A drop or two of the selected solution should be instilled every hour or two until relief is obtained; if this does not occur, the drug should be abandoned and an operation at once undertaken.

In addition to the use of eserine during an acute attack, the temple may be leeched, warm fomentations applied, and rest and relief from pain secured by the exhibition of full doses of morphine and chloral, the latter drug having some influence in reducing tension. Advantage may further be gained by giving a purge and a sedative fever mixture. Medicinal treatment is only a temporary matter and must not be relied upon.

In chronic inflammatory glaucoma and in the simple variety the indication for eserine, unless there are subacute attacks, is not so clear. Still, if the tension is above normal, this drug, or its substitute, may be employed until it is decided what operation shall be done and when it shall be performed. The energetic use of eserine causes some irritation of the ciliary body and spasm of accommodation, and, as has been stated, strain upon the

accommodation predisposes to glaucoma. Hence if eserine is to be used continuously it is better not to employ it in a too strong solution (gr. $\frac{1}{24}$–$\frac{1}{6}$–$\bar{3}$j will suffice), and, in the belief of some surgeons, pilocarpine is preferable. This congestion of the ciliary processes induced by eserine, sometimes entirely defeats its proper action. Another point, although a minor one, is that its continuous use tends to cause a follicular conjunctivitis in some eyes.

Iridectomy is the best method of treating glaucoma. General anæsthesia should be induced before its performance, because the high tension of the eyeball somewhat nullifies the action of cocaine. Much depends upon the exact position of the iridectomy, which is difficult of performance on account of the narrow anterior chamber, and no caution should be omitted which will secure perfect quiet on the part of the patient.

The following points must be observed: (1) About one-fifth of the iris should be excised, the detachment being made up to the periphery by cutting first one side of the portion of the iris which has been drawn out of the wound, then dragging it across to the other angle and completing the excision, thus removing everything up to the ciliary border. (2) The wound should be sufficiently large to permit of such extensive detachment of the iris. (3) The point of selection for the entrance of the keratome should lie in the sclerotic coat about 2 mm. from the apparent border of the cornea. (4) The knife should be withdrawn slowly from the anterior chamber in order to prevent a sudden gush of aqueous humor, and a too rapid reduction of tension which might be followed by intraocular hemorrhage. (5) Great care must be taken that no portion of the excised iris remains in the angles of the wound.

A favorable result is indicated if the tension is lowered; an unfavorable one if this remains high. If there is a sudden rise of tension a short time after the operation, accompanied by severe pain, there is reason to believe that intraocular hemorrhage has taken place.

The cutting of the iris is oftened followed by an extensive hemorrhage into the anterior chamber. A prolonged effort to get rid of this blood should not be made lest the trituration produce

cataract. The blood will absorb, although it may take many days and even weeks before this is entirely accomplished.

The reforming of the anterior chamber is sometimes delayed as long as a week. Occasionally, a day or two after the operation there is some slight rise of tension in the eye, which is of temporary character.

There is difference of opinion in regard to whether the eye should be bandaged or not, after operations of this character. The author believes that not only should a bandage be applied, for the first few days, to the eye upon which the operation has been done, but also to the fellow eye; and that the one placed upon the affected organ should remain there until complete restoration of the anterior chamber has taken place by healing of the wound. In most instances it is best to perform the iridectomy directly upward, so that the overhanging upper lid may cover the coloboma. It may be necessary, in the event of one iridectomy failing, to repeat the operation. It is a wise precaution to instil eserine into the eye which has not been operated upon, during the course of the treatment.

One of the complications which may follow the operation of iridectomy in glaucoma, is the formation of a bulging scar at the seat of incision, sometimes called a *cystoid cicatrix*. This is especially true if due care has not been taken to free the angles of the wound from adherent iris. On the other hand, in bad cases, this very cystoid cicatrix, by permitting a filtering of the liquids, has been looked upon as a favorable condition.

The treatment of chronic inflammatory glaucoma and simple glaucoma by iridectomy is less likely to be followed by brilliant results than in acute cases; and numbers of instances are on record in which after the performance of an operation, entirely classical in its technique, the disease has not been stayed. Depreciation of vision may occur, partly due to the astigmatism which has been produced by the operation.

An operation should be done before much contraction of the field has occurred. Some surgeons, like Nettleship, believe that the state of the pupil and its reaction to eserine furnish a good prognostic guide for operative interference in chronic glaucoma.

The conclusions of Gruening in regard to this matter are as

follows: In chronic inflammatory glaucoma without a degenerative change in the iris, a satisfactory result follows a careful iridectomy. If, however, there is degenerative change in the iris, iridectomy does not give the desired relief. In simple glaucoma iridectomy generally maintains the condition of vision which was present before the operation, other things being equal, and consequently is a proper surgical procedure.

Even if there is a good deal of contraction of the field, and the optic disc quite pale (provided the patient is not too far advanced in life), it would seem proper to attempt an operation, especially if both eyes are affected. Bull's advice, after all the chances of success and failure have been fairly stated, is "to operate in cases of chronic progressive glaucoma, and the earlier the better." Schweigger teaches that it is advisable to operate in chronic glaucoma affecting both eyes, first upon the worse one, even if it is blind. Should the healing process be normal, the second eye may be operated upon without fear.

Other operations for the relief of glaucoma have been practised and with alleged good results. Thus, repeated paracentesis of the cornea will relieve the tension, but gives only temporary results. Trephining the cornea has been tried, and stretching the external nasal nerve was introduced by Badal, and may suffice to relieve pain, being sometimes applicable in cases of blind eyes in which it is desirable to avoid the operation of enucleation.

The operation of *sclerotomy*, or puncture and incision of the sclerotic, has been used as a substitute for iridectomy, but the weight of testimony in favor of the latter operation is sufficiently great not to make this a desirable mode of procedure except in selected cases. In point of fact every iridectomy, which is peripherally situated, and in which the knife enters through the sclera some distance from the apparent border of the cornea, is in itself a sclerotomy, having the additional advantage of being associated with excision of the iris.

It is not entirely certain how iridectomy cures glaucoma. It has been suggested that this is accomplished by the removal of the portion of tissue which closes the angle at the anterior chamber; by the moderation of the blood pressure in the iris (Exner); or by the filtration of the fluids of the eye, through the line of

healing, which, for this reason, has been called the *filtration scar*. The details of performing iridectomy and sclerotomy will be described in the chapter devoted to OPERATIONS.

Secondary Glaucoma, or that form which arises in consequence of some pre-existing disease of the eye, may, like the primary variety, assume an acute or chronic type.

It may follow inflammation of the iris and ciliary body with the production of extensive synechiæ; ulcers of the cornea which have perforated and produced considerable anterior synechiæ or staphylomatous bulging; swelling of the crystalline lens, after discission; dislocation of the lens; detachment of the retina, associated with severe hemorrhage; the growth of a choroidal sarcoma or other intraocular tumor; and choroido-retinitis or disease of the retinal vessels.

In most of the instances mentioned there is no difficulty in diagnosticating secondary glaucoma by the history of the case, and the knowledge of the pre-existing disease. This is not so easy if the original trouble has been deep in the eye, like a sarcoma. In these cases the type of the disease is usually absolute.

TREATMENT.—Secondary glaucoma requires the same treatment as in the primary form of the disease. A dislocated lens, or a lens swollen after discission for cataract, should be removed. The formation of absolute glaucoma associated with great pain, and if there is any suspicion of intraocular growth, indicates excision of the globe.

Hemorrhagic Glaucoma is one type of secondary glaucoma, in which numerous retinal hemorrhages appear as the result of thrombosis of the retinal vessels, or from other causes likely to produce extravasation of blood (albuminuric retinitis). The tension rises and the character of the disease may be either acute, subacute, or chronic.

If seen at a time when there are numerous retinal hemorrhages and the ordinary ophthalmoscopic appearances of glaucoma, it is quite impossible to decide whether the glaucoma is secondary to the hemorrhages, or the hemorrhages simply associated with the glaucoma.

In these cases iridectomy is not usually followed by good results. It may lead to permanent blindness by fresh hemorrhagic

exacerbations. Eserine may be tried if the tension is high, but is generally unavailing. It is said that sclerotomy is more favorable than iridectomy, and tapping the vitreous has its advocates. Some good may be accomplished by regulation of the patient's mode of life and the cautious use of cardiac sedatives.

Complicated Glaucoma.—Two kinds of complicated glaucoma are described which may be looked upon as varieties of the secondary form of the disease, namely, *cataract with glaucoma*, and *high myopia with glaucoma*. In the former condition one eye alone is usually affected. This complication does not refer to those eyes which go on to absolute blindness from glaucoma, or to contain opaque lenses as the result of a general degenerative process of the eye.

In high myopia with glaucoma, the usual symptoms in the field of vision and the papilla are present. In addition to this there is more or less choroidal change, which is itself the cause of the glaucomatous attack.

Hydrophthalmos, or that disease of the eye which has been looked upon as a congenital glaucoma, has been described on page 294.

CHAPTER XIII.

DISEASES OF THE CRYSTALLINE LENS.

Congenital Anomalies.—In addition to congenital cataract and congenital displacement of the lens, which are described on page 393, two anomalies require mention.

1. *Coloboma of the Lens.*—This defect occurs usually with a similar defect in the iris and choroid. The normal, rounded margin of the lens is replaced by a straight margin in a horizontal direction, or incurved. The amount of the defect varies from a slight indentation to about one-quarter of the lens substance. It is always situated in the inferior half of the lens (Heyl).

2. *Lenticonus.*—This deformity is exceedingly rare, and consists of a transparent conical projection from the posterior surface of the crystalline lens. In Knapp's case there was no lenticular opacity. The plane mirror showed a sharp, red disc, surrounded by dark shadows, like an oil globule in water.

Cataract.—Under the general term *cataract* are included several types of an opaque condition of the crystalline lens, of its capsule, or of both these structures, which anatomically are distinguished by the titles *lenticular*, *capsular*, and *capsulo-lenticular*.

Varieties of Cataract.—(a) *Primary;* and (b) *secondary* to disorders in other portions of the eye, or (c) *symptomatic* of a general malady, or local injury.

A cataract is either *partial* and stationary, or progressive and becomes *complete*, and clinically is classified as *senile*, subdivided into *nuclear* and *cortical;* *congenital* or *juvenile*, subdivided into *complete* or *partial;* *secondary*, or *complicated;* *traumatic;* and *after-cataract.*

Cataracts are also classified according to their consistence as *hard*, *soft*, or *fluid*, and sometimes are designated by their color as *black*, *white*, *amber*, etc. Although in many instances

the precise division of cataract into special varieties may be unimportant, the following table, compiled from the classifications employed in various standard works, may be useful to the student as a *résumé* of what has gone before :—

- **Anatomically**
  1. Lenticular.
  2. Capsular.
  3. Capsulo-lenticular.
- **Clinically**
  1. Senile — (*a*) cortical, (*b*) nuclear — general.
  2. Juvenile or congenital
     - (*a*) complete — complete. / congenital.
     - (*b*) partial — lamellar, or zonular. / pyramidal, or polar.
  3. Complicated or secondary
     - anterior polar cataract.
     - posterior polar cataract.
     - complete cataract.
  4. Traumatic.
  5. After-cataract.

Symptoms.—The following symptoms are present with more or less constancy in cataract, exemplified by the senile form of this disease.

(1) *Change in Visual Acuity.*—The amount of depreciation of sight depends upon the situation and extent of the opacity. In incipient cataract the swelling of the lens may increase the refraction of the eye. The so-called "second sight," or the ability of patients of advanced years to dispense with reading glasses, in itself is strong presumptive evidence of the existence of cataract. In like manner the change in the lens may produce an astigmatism, or alter one previously existing "according to the rule" into one "contrary to the rule," *i. e.*, where the meridian of greatest refraction is in a direction contrary to the rule.

(2) *Hyperæmia of the Conjunctiva.*—This is caused by the strain which the effort to see through a somewhat clouded lens produces.

(3) *Pain and Photophobia.*—These symptoms are not prominent; but sometimes, owing to the condition of disturbed choroid which commonly is associated with cataract, patients complain of dull aching pain, or other asthenopic symptoms. Tinted glasses relieve the photophobia and permit slight dilatation of the pupil, which somewhat improves vision if the opacity is central.

(4) *Polyopia and Monocular Diplopia* are occasionally the result of incipient cataract.

(5) *The Anterior Chamber.*—This may be normal in depth—the usual condition; shallower than normal—indicating a swollen lens; or abnormally deep—a symptom of small lens.

(6) *The Pupil.*—This may be natural in appearance and the mobility of the iris entirely normal; but sometimes the effect of exclusion of light, or of a mydriatic, fails to induce a dilatation of the pupil.

We speak of the "color of the pupil," and this varies in cataract according to the degree of maturity and the hue of the opacity. Hence, in the unilluminated pupil, no change is seen in its color in incipient cataract; but in a ripe cataract, the pupillary space may appear dull, gray, and even white, according to circumstances. In examples of so-called "black cataract" the pupil is dark. The mere inspection of the pupil, however, without optical aid, is not necessarily a criterion of the condition of the lens, which continues to increase in size even with advancing years, if it remains clear. (Priestley Smith.) But it becomes firmer, straw-colored, and reflects more light. This creates a dull sheen in the pupil which may be mistaken for cataract.

Diagnosis.—From what has been said, it is apparent that the absolute diagnosis of cataract depends upon the use of the ophthalmoscope. Since the introduction of the ophthalmoscope, the *catoptic test* has fallen into disuse, although it may be employed to determine the presence of the lens, and in the diagnosis of black cataract.

This test is performed as follows: If, in a dark room, a lighted candle be moved before a healthy eye with dilated pupil, three images of the flame will be seen; two erect, formed by reflection from the convex cornea and anterior surface of the lens, the former producing the bright image and the latter the more diffuse; and one inverted, relatively clearer, from the posterior surface of the lens. If, now, the lens be opaque, the inverted image will be wanting, the deeper erect image also disappearing when the opacity involves the capsule, the corneal image being then alone visible.

Before using the ophthalmoscope for the detection of cataract, the pupil should be dilated, preferably with homatropine or cocaine. The examiner then proceeds in the manner described

on page 104, and will detect in incipient cataract spots or streaks of opacity, often radiating from the periphery toward the centre, which appear black from the interference with the reflection of light from the choroid. In like manner the nucleus may be seen to be hazy and the periphery clear, or the sectors of the lens are strongly marked. The beginning of cataract is also made evident by flaws in the lens, which have been compared to cracks in glass, and are known as "striæ of refraction." If the entire lens is opaque, no portion of the pupillary space exhibits any red reflex from the fundus, although a lens which appears completely cataractous through the undilated pupil, may exhibit spots of incomplete opacification in the periphery, recognized by the transmitted red glare, when the pupil is dilated. The final examination with transmitted light should be made with a + 16 D lens.

With *oblique illumination* (page 62), the opacities, if incipient, appear as white or gray streaks and dots.

When a progressive senile cataract is fully matured, its presence may often be detected without any special examination, except in the instances already mentioned, but it is a matter of the utmost importance to ascertain when this full maturity has been reached, or, in other words, whether the cataract is "*ripe*." This is determined in the following manner:—

The patient being placed in proper position, the pupillary space is illuminated. If the opacity is complete, the opaque lens, covered by its capsule, is level with the margin of the pupil, and there is no shadow; if not, the major portion of the opacity is at a level posterior to the plane of the pupil, or, in other words, a clear or partly clear space is present between the iris and the opaque portion, and a dark semicircle appears upon the opacity at the side from which the light comes. This is the shadow of the iris. (Fig. 115.) Shining sectors or the transmission of a red glare indicate immaturity, even if the shadow is absent. In

Fig. 115.



Shadow of the iris seen from the front, appearing on that side of the iris which is toward the light, *L* (Fuchs).

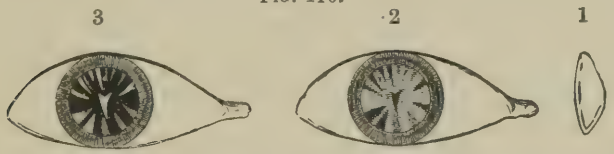
hypermature cataract the shadow is visible, but the surface of the lens is flat.

Development and Course of Cataract.—In progressive *senile*, or as it is sometimes called, *simple* cataract, there is a period of growth from incipiency to full maturity which varies considerably, and consumes from one to three years or longer.

Immature cataract, especially of the cortical variety, may remain unchanged for many years. According to Brailey the indications are that senile *nuclear* cataract is a degenerative change, while the *cortical* variety partakes of the nature of an inflammation. This slow progress of cortical senile cataract should be remembered, and the discovery of striæ in the lens need not condemn the patient to rapid deterioration of vision.

The opacities begin either *equatorially*, *i. e.*, at the edge of the lens; or *centrally*, *i. e.*, at the nucleus. In the former case the striæ begin just beneath the capsule and are seen both in the anterior and posterior portions. They gradually radiate toward the centre (encroach on the pupil-space), the nucleus becomes hazy and sclerosed, the cortical layers become opaque, and finally the cataract is complete.

Fig. 116.



Cortical cataract. 1. Section of lens; opacities beneath the capsule. 2. Opacities seen by transmitted light (ophthalmoscope mirror). 3. Opacities seen by reflected light (oblique illumination). (Nettleship.)

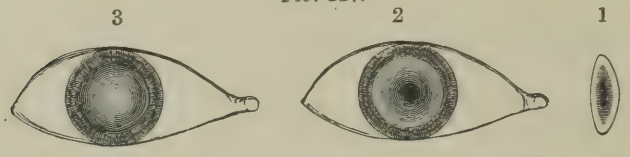
The participation of the nucleus and the cortex is sometimes spoken of as *mixed cataract*.

In the second variety the nucleus becomes hazy and the surrounding cloudiness always remains the most opaque portion of the cataract, which gradually spreads to the cortex. (Fig. 117.)

According to Schoen, senile cataract invariably begins as equatorial cataract, with fine white dots and streaks, while the nuclear sclerosis never appears without equatorial cataract, being secondary to it, the association occurring first after the sixtieth year.

Cataract may also begin as a more or less diffuse clouding, or in the form of small dots, scattered through the cortex, or in opacities which, with transmitted light, resemble dark flocculent precipitates. Under the last circumstances the advance is more

Fig. 117.



Nuclear cataract. 1. Section of lens, central position of opacity. 2. Appearance by transmitted light. 3. Appearance by oblique illumination. (Nettleship.)

rapid than when striæ are the first manifestation. (Swanzy.) Instead of going on to maturity, a nuclear haze or a spear of opacity may remain stationary, or at least show no practical change for years.

A cataract having reached maturity may proceed to the stage of "over-ripeness" and gradually shrink to a flat disc, or there may be liquefaction of the cortical matter and displacement of the nucleus, a type which is known as *Morgagnian cataract.* Tremulousness of the iris is seen in over-ripe cataracts. Fatty changes and calcareous degeneration in the lens and its capsule may take place. Cataracts which have been caused by diabetes may undergo spontaneous absorption; it seems doubtful if the same phenomenon ever occurs with ordinary senile cataract, although one or two examples have been reported.

The cataract, the development of which has just been described is for the most part "*hard*," *i. e.*, the nucleus of the lens is large. Under the age of thirty-five all cataracts are "*soft*," *i. e.*, the nuclei are small or wanting, just as the lenses in which they develop have failed to attain the density which later they assume.

Causes of Cataract.—(1) *Age of Life.*—The formation of that form of cataract which becomes complete is especially frequent after fifty years, but occasionally total cataract without apparent constitutional cause is found in adolescents. The very

beginnings of cataract, according to one observer, are not peculiar to old age, but appear between the twentieth and thirtieth years as an equatorial cataract.

(2) *Sex.*—This appears to have no decided influence, the sexes being about equally affected, unless it be in the zonular variety, in which the greater liability of females has been recorded.

(3) *Disease.*—Sugar has been found in the urine of about one per cent. of cataract cases, and the cataractous lenses of patients, the subjects of diabetes mellitus, at times contain sugar. An examination of the urine should always be made in cataract cases, especially when developed in young subjects, and sugar carefully sought for. Albumin is present in about 6 per cent. of the cases, but its etiological relation to cataract has not been proven.

Cataract has also been noted in connection with epilepsy and other types of convulsions, often nuclear in its early stages; with bronchocele, perhaps from pressure on the carotid; with atheroma of the carotid; with certain cutaneous diseases; and after meningitis.

(4) *Occupation.*—Cataract is especially frequent among glass-blowers and is attributed to the effect of the radiated heat and excessive perspiration. It is not improbable that investigations would show the same liability in puddlers and others exposed to intense heat.

(5) *Heredity.*—Remarkable examples of the influence of heredity in the formation of cataract have been published. It has been noted that the tendency is more marked in the child-bearing period, and that the transmission is through the female line; transmission through the male line only, however, has been recorded.

(6) *Toxic Agents.*—Cataract has been produced artificially by poisoning rabbits with naphthalin (*naphthalin cataract*). In addition to the cataract, there are changes in the retina and vitreous, and also general disturbances.

During epidemics of *ergotism* patients are at times affected with cataract, the appearance having been noted almost exclusively in the convulsive type of this toxæmia; hence it is not certain whether the lenticular opacity results from the poisoning by the ergot, or on account of the violent general convulsions.

(7) *Traumatism.*—This may produce cataract by a *direct* injury to the lens, or in an *indirect* method, for example, by a concussion (*concussion cataract*).

To this category belong those cataracts which have followed a lightning stroke. A number of examples are recorded, both double and single, partial and complete. In addition to the cataract, optic neuritis, optic atrophy, rupture of the choroid, iritis, myosis, mydriasis, and palsy of accommodation have been observed.

(8) *Diseases of the Eye.*—Cataract may be secondary to numerous acute and chronic affections of the eye, viz., iritis, irido-cyclitis, irido-choroiditis, choroiditis, detachment of the retina, glaucoma, and diseases of the cornea, especially sloughing ulcers. The frequent coexistence of disturbance of the choroid coat and incipient cataract has led to the opinion that while opacity of the lens (so-called senile) is a condition commonly seen in advanced life, it does not, in all probability, depend upon senile changes, but is originated in local pathological states involving the nutrition of the eye itself (Risley).

(9) *Accommodative Strain.*—Investigations show that a large majority of cataractous eyes are hypermetropic and astigmatic, and that the danger of cataract is increased when the astigmatism is against the rule, and remains uncorrected. The evident prophylactic measure is the use of proper glasses.

The etiology of cataract is by no means always clear, and often several factors are necessary to explain it; often no direct cause can be assigned; often there are extraocular causes and the cataract results from nutritive disturbances.

The following additional facts in regard to the clinical varieties deserve attention :—

I. Senile Cataract (*Simple Cataract, Gray Cataract*).—This, representing the type of general cataract, is nuclear, cortical, or mixed in its origin, and is rare before the forty-fifth year. It may not appear before the sixtieth year. Its course from incipiency to full maturity has been described.

The color usually is gray, and the nucleus, which itself does not become cataractous, but is hardened, may be recognized by

its yellowish or brownish hue, sometimes being waxy in appearance.

If the nucleus is small and the surrounding cortex uniformly white, the cataract is comparatively *soft;* if the nucleus is large and the color of the cataract distinctly gray, or yellowish or brownish, it is *hard.*

Instead of a gray or grayish-white color, the cataract may be yellow or amber, or the sclerosis of the nucleus extends to the cortical substance so that the whole lens is brownish and the pupil black (black cataract).

Senile cataract generally is bilateral, one eye being more affected than its fellow. Occasionally a ripe cataract occurs upon one side only, the other lens being not at all or only slightly affected.

II. Juvenile, or Congenital Cataract, appears in the form of a complete or partial opacity of the lens, and is comparatively a rare affection.[1]

In the complete form, the lens usually is white or bluish-white in color, densely opaque, and *soft.* The eye may be otherwise healthy, or there may be changes in the choroid, retina, optic nerve (congenital amblyopia), and sometimes vices of conformation, like coloboma, microphthalmos, and hydrophthalmos. Disturbances of nutrition during intrauterine life, changes in the choroid, arrest of development, and heredity, have been invoked to explain its existence.

In forms of cataract developed in early life the evidence of the influence of heredity is often strong; more usually this is lacking in the congenital types.

General cataracts in young people (*complete cataract of young people*), may arise without known cause. These are bluish-white, often have a sheen like pearl, and are soft.

Diabetic cataract is also complete, and may be soft or hard according to the age at which it develops.

There are several varieties of *partial* congenital cataract:—

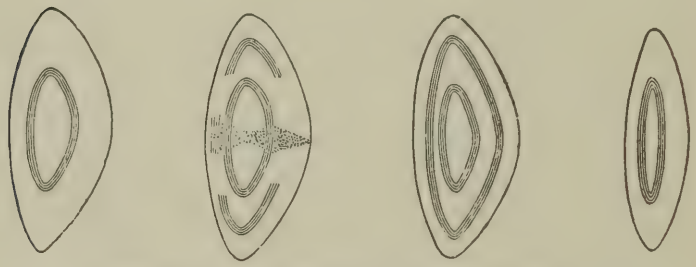
(a) *Zonular, or Lamellar Cataract* appears, as its name implies,

[1] In the tables of De Wecker, among 40,000 cases of various forms of eye disease, 36 total congenital cataracts are enumerated.

in the form of an opaque layer surrounding the clear centre of the lens. Usually it is double, but may be unilateral, and is either congenital, or forms in early infancy. The cataract is stationary in most instances, but occasionally becomes complete.

If the centre of the pupil is examined, a reddish point surrounded by a grayish halo will be observed. When the pupil is dilated with atropine and examined with the ophthalmoscopic mirror, the central dark zone will be apparent, surrounded by a reddish circle, due to the reflection from the fundus passing through the peripheral part of the lens, which remains clear. A rare type is several zones of opacity separated by zones of transparency. Patients with zonular cataract act like myopes.

Fig. 118.



Varieties of zonular cataract seen in section (Meyer).

The cause of lamellar cataract is not certainly known. In the congenital variety it is probably due to some developmental defect; in the variety arising in early infancy some fault in nutrition has occurred. Most often the subjects are rachitic, and present the teeth and cranial asymmetry peculiar to this affection. A history of convulsions is common, and the dental defects, which are present in the form of lines, furrows, or terraces running transversely across the incisors or canines, are considered by Hutchinson to be due to the mercury which in all probability was given for the convulsions which caused the cataract. Anatomically, lamellar cataract consists of a narrow zone of degenerative change in the lens fibres, situated between the nuclear and cortical areas (Lawford).

(b) *Central Cataract* (*Central lental cataract*) consists of a white opacity in the central part of the lens, due probably to faulty development at an early stage of intrauterine existence. Sometimes vision is surprisingly good, in one case in the author's practice amounting to $\frac{6}{9}$; at other times it may be poor, and defects of development in the eye may be present and nystagmus may develop.

(c) *Pyramidal Cataract.*—This is also known as *anterior capsular* or *polar cataract*, and consists of a small, pyramidal-shaped opacity due to hyperplasia of the capsular epithelium. Mules suggests that these cataracts may be cretified remains of the pupillary membrane, with or without a lymph cone.

At the posterior pole of the lens an opacity similar to the one described may be found, known as a *posterior polar, or pyramidal congenital cataract.* It is caused by vestigial remains of the hyaloid artery at its lenticular attachment. These opacities are sometimes separated into those which lie beneath the capsule and those which exist upon its surface.

(d) *Punctate Cataract* is an unusual form of congenital lenticular change in which the opacities present themselves in the form of more or less fine points, occupying the centre of the pupillary space. The cataract remains stationary for a long time.

(e) *Fusiform Cataract* is a rare variety characterized by an opaque stripe passing from the anterior to the posterior pole of the lens. It may be combined with zonular cataract.

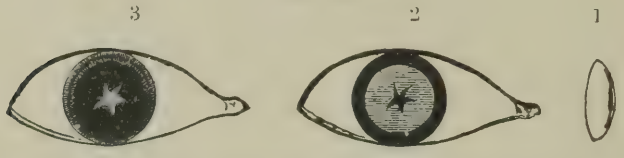
III. Complicated, or Secondary Cataract.—This may be *complete* and arise in consequence of the various diseases of the eye enumerated on page 392. Calcareous changes are often seen in such cataracts. It may also be *incomplete,* and then is classified in the following varieties:

(a) *Anterior Polar Cataract.*—In addition to the congenital variety of this opacity there is an acquired type, already described on page 222.

(b) *Posterior Polar Cataract,* as a congenital variety, has been described; but another form is the more or less star-shaped opacity sometimes seen at the posterior pole of the lens in high myopia, vitreous disease, disseminated choroiditis, and pigmentary

degeneration of the retina. It may remain stationary for a long time, disturbing vision in proportion to its density, or it may progress and become complete.

Fig. 119.



Posterior polar cataract. 1. Section of lens showing portion of opacity; 2. Appearance by transmitted light; and 3, by oblique illumination. (Nettleship.)

IV. Traumatic Cataract.—This occurs by *direct* injury to the lens by some penetrating substance, which lacerates the capsule and then permits the entrance of the aqueous humor. The lens substance swells up, becomes opaque, and some of it may escape into the anterior chamber. Absorption takes place in about six weeks. This course represents the most favorable outcome of such an accident. In other cases there may be iritis, cyclitis, and secondary glaucoma, owing to the swelling of the lens.

Instead of going on to complete opacity, an injured lens, in some instances, presents a limited opacity, which remains stationary; in other instances this disappears, and in still others there is slow advance of the opacity.

The opacity is explained by the action of the sodium chloride of the aqueous humor upon the globulin of the lens-substance.

A more *indirect* mechanism of traumatic cataract is *concussion* (*concussion cataract*)—a blow upon the eye causing a slight rupture of the anterior or posterior capsule, followed by opacity, which may become general or retain a limited size for a long time. According to Nettleship, absorption of a complete concussion cataract is more uncommon than when the lenticular opacity has followed a direct trauma, although the lens may gradually shrink in size.

V. After-Cataract.—This name has been applied to those changes which occur in the capsule of the lens remaining after the extraction of cataract. It is usually called *secondary cataract.*

These changes are either closure of the opening made in the

capsule, opacity of the capsule itself from proliferation of its cells, or increased thickening in the capsule which may have existed before the lens was removed. The name has also been given to deposits of lymph, plastic exudate, and occlusion of the pupil which have followed unsuccessful cataract operations.

VI. Capsular Cataract.—The name *capsular cataract* is applied to thickenings and proliferations of the capsular epithelium which may be congenital, may follow inflammatory processes of the eye (corneal ulcer), and may occur in connection with other degenerations in over-ripe cataract.

VII. Capsulo-lenticular Cataract is the name applied to opacity of the lens associated with thickening of the surrounding capsule, most commonly in the centre of its anterior portion.

Prognosis.—Incipient cataract in the form of striæ in the anterior cortex, need not doom the patient to rapid deterioration of sight, because the existing vision is often maintained for long periods of time. Cataracts, however, do not spontaneously disappear, except in rare instances.

Operation is generally deferred until the cataract is "*ripe*," but even then it must be ascertained whether the eye itself is in a healthy condition by attention to the following considerations :—

(a) *The Probable Condition of the Interior of the Eye*, if no data of ophthalmoscopic examinations during the incipiency of the cataract are at hand. This is ascertained as follows :—

Place the patient before a lighted candle about four metres distant—the flame should be distinctly recognized. This gives evidence that the macular region is free from coarse disease. Now cause the eye under examination to fix the flame attentively; and move a second lighted candle radially through the field of vision. The flame should be recognized as soon as the rays strike the edge of the cornea, and the patient should be able to indicate the direction in which it is coming. Thus the "light field," or the "projection of light," is tested, and, if the answers have been accurate, "projection of light is good in all parts of the field."

If the patient fails to appreciate the candle flame in any portion of the field, coarse changes may be suspected, *e. g.*, extensive choroiditis, detachment of the retina, glaucoma, etc. Fluid

vitreous, indicated by tremulousness of the iris, is a bad sign. Should there be no light-perception, the case is an unsuitable one for operation. Even with these precautions, a perfect cataract extraction may fail to secure good vision on account of a small patch of central choroiditis.

(b) *The Probable Condition of the Refraction.*—It may be quite impossible to ascertain this unless some record is at hand of an examination when the media were still clear. Some idea of the refraction is obtainable by examining the glasses which the patient may have used during his reading days. High myopia renders the prognosis unfavorable; indeed, the vision after operation in myopic cases, other things being equal, is not so good as that in hypermetropes.

(c) *The Mobility of the Iris; its Reaction to a Mydriatic.*—This should be prompt and normal. Failure of pupillary reaction in either case may indicate imperfect conductive power in the optic nerve, or atrophy or other change in the iris.

(d) *The Age and General Condition of the Patient.*—Advanced age does militate, as much as it would seem likely to do, against successful cataract extraction. So, too, the extraction of diabetic cataract is often followed by good results; and even the presence of chronic Bright's disease, while a complicating circumstance, does not forbid the operation. Great feebleness, dementia likely to become worse with confinement, and chronic bronchitis, are unfavorable conditions.

(e) *The Condition of the Area of Future Operation and of its Surroundings.*—Disease of the lachrymo-nasal channels, granular lids, chronic conjunctivitis, or blepharitis contraindicate cataract extraction, because the wound is almost certain to become infected by the unhealthy discharges. A fact of importance, not always attended to, is the state of the posterior nares. This should be reasonably healthy to secure the highest type of success.

(f) *The Type and Condition of the Cataract.*—In making a prognosis the size of the nucleus and its position, the probable consistence of the cortex, the primary or secondary nature of the cataract, and its stage of maturity must be considered. Special considerations (amblyopia) influence the prognosis in complete congenital cataract, and in the partial varieties, like the lamellar

form, as the eye may be of imperfect construction. In traumatic cataract the extent of injury to parts other than the lens must be regarded.

Treatment.—This may be divided into the treatment of *immature* and *mature* cataract.

Drugs do not exist which can dissolve a growing cataract; and the use of electricity, which has been recommended, is of doubtful value. None the less, much comfort can be given to a patient with incipient cataract by attending to the following directions:—

(1) The refraction should be carefully tested and that glass ordered which gives the most accurate vision. It may be necessary to make frequent changes in the correcting lenses, to conform to the alterations in refraction brought about by the swelling of the lens.

(2) The common congestion of the choroid coat is relieved by the exhibition of certain alteratives, among which the iodides of soda and potash are the most suitable. These may be combined with small doses of bromide of potash or bromide of soda. Tonic doses of strychnia or tincture of nux vomica likewise serve a useful purpose. If by these means the asthenopic symptoms are relieved the moderate use of the eyes may be permitted, without danger of hastening the process of maturation.

(3) If glasses do not avail, some comfort may be given by keeping the pupil dilated with a weak mydriatic (if the opacity is central), and thus improving vision. In other cases a myotic is useful.

Artificial Ripening.—The exceeding slowness with which a senile cataract may progress often leaves the patient in a stage of semi-blindness and yet with insufficient maturity of the cataract to justify an extraction. To remedy this, several methods have been proposed for hastening the process of ripening.

Förster's method is as follows: An upward iridectomy is performed, and the lens fibres bruised or broken by rubbing the cornea over the coloboma with a horn spoon, or similar smooth instrument, but without rupture of the capsule. Rapid increase in the opacity often follows this procedure, and when it is complete the extraction may be made. Other operators insert a small

spatula through the opening in the cornea and press directly upon the lens, thus accomplishing the same purpose.

Before the fortieth year a discission, after the manner of Graefe, carried deep into the lens substance, has been recommended to secure total opacity; after this age, the trituration-process just described is preferable.

Extraction of Immature Cataract.—Some operators of extensive experience (Schweigger) hold that the usual criteria of ripeness—opacity to the periphery, and the absence of the shadow of the iris by lateral illumination—are erroneous in that period when accommodation is annulled by physiological changes in the lens, that is, about the sixtieth year, and the lens may be extracted safely even if it is in part unclouded.

Finally, certain operators (McKeown, Wickerkiewicz, Panas, Lippincott) perform extraction of immature cataract by the help of a syringe with which the tenacious cortical material is washed out by the injection of warm distilled water, or boric acid solution.

If the unripe material is not removed it will swell up and may produce disastrous inflammation. Therefore, most surgeons prefer to wait until the cataract is "ripe," and thus avoid one source of danger in the operation.

Mature cataract requires an operation for its removal, differing according to the age of the patient and the consistency of the cataract.

Hard cataracts, or those which occur after the fortieth year, are suitably removed by one or other of the following methods: (*a*) The flap method, or simple extraction (extraction without iridectomy); (*b*) the modified or peripheral linear extraction (Von Graefe); (*c*) the short or three millimetre flap (De Wecker).

Soft cataracts, or those which occur before the thirty-fifth year, are suitably removed by (*a*) linear extraction; (*b*) the needle operation, or that of solution by discission; and (*c*) the suction method. A soft cataract before the twenty-fifth year may be removed through a linear incision into the cornea, and a semi-fluid one by suction. Complete cataract of young people and complete congenital cataract are generally removed by discission, the latter variety of cataract being ready for operation after the completion of dentition.

Partial congenital cataracts (central, lental and lamellar) are treated by iridectomy or by discission. The former procedure is better if, after dilatation with a mydriatic, there is sufficient improvement in vision to justify the manufacture of a new pupil. This should be made opposite to the clearest part of the lens. If this does not prove satisfactory the lens may be needled, or, finally, the entire lens may be extracted.

Discission is the method of operating applied to after-cataracts. Pyramidal cataract, both of the anterior and posterior polar variety, is not generally amenable to operative treatment.

Usually it is not wise to extract a cataract from one eye, if the lens of the fellow organ is free from opacity, or if the eye retains good acuity of vision, because the high grade of inequality in refraction produced by the operation will not give the patient increased visual acuity ; the two eyes will not work together. As a cosmetic operation it may sometimes be done.

The technique of performing the various methods of cataract extraction, the dangers and accidents, will be described on page 602.

After a successful extraction or solution, and after sufficient time has elapsed to secure firm healing, a suitable pair of lenses should be adjusted—one for distant vision and one for reading.

Removal of the crystalline lens produces the condition technically spoken of as *aphakia*, and causes a high degree of hypermetropia, in the emmetropic eye corresponding to about 11 D. The degree of hypermetropia will be diminished if the previous refraction has been myopic, and it is possible to produce emmetropia, provided the former nearsightedness has been of such degree that the removal of the lens exactly neutralizes it.

Under ordinary circumstances the correcting lens for distant vision is about + 10 D. The glass for reading and similar occupation should be placed from sixteen to twenty-five centimetres from the eye, according to the usual acuity. In other words, a lens having a focal distance of 16–25 cm. is added to the distance glass.

In addition to the hypermetropic refraction which follows cataract extraction a certain amount of regular astigmatism is the result of the operation, due probably to failure of the wound to

heal properly. This astigmatism is generally "contrary to the rule," and is often higher during the first month or two after the extraction, or until cicatrization is complete. Usually not more than 3 D remains permanently, but even 1 D should be sought out and corrected. The astigmatism may diminish during the first two or three months after operation.

Glasses should not be adjusted until all redness has disappeared from the eye, and they should not be worn constantly at first. It is wise to wait from six weeks to two months before ordering the glasses for constant use.

The amount of vision obtained after a cataract extraction varies considerably. Perfect acuity of sight is sometimes secured, *i. e.*, $\frac{6}{6}\left(\frac{20}{xx}\right)$, but more often patients must be content with lower degrees, $\frac{1}{8}$, or, according to some operators, $\frac{1}{10}$ of normal vision being considered sufficient to place the case within the category of successes.

Acuity of vision may frequently be considerably raised by needling the capsule of the lens which remains behind, and some surgeons perform this operation almost as the rule. (See OPERATIONS.)

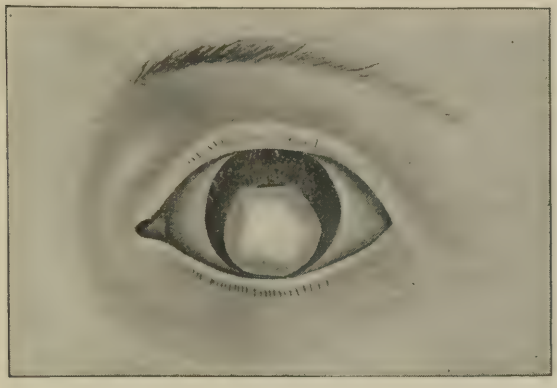
Dislocation of the Crystalline Lens.—This may be congenital (*ectopia lentis*), and is then due to a relaxation or absence of the zonula. The displacement ordinarily is *incomplete*, and really consists in a decentration of the lens; but *complete* congenital luxation is also described, and may occur as a monolateral or bilateral displacement.

In addition to congenital dislocation there are those due to disease of the eye, *e. g.*, choroiditis, malignant myopia, etc., and those caused by traumatism. This dislocation may also be *incomplete* or *complete;* if the latter, the lens may be dislodged from its normal position backward into the vitreous, forward into the anterior chamber, or, through a wound, beneath the conjunctiva, and even under Tenon's capsule.

SYMPTOMS.—If the dislocation is partial, the margin of the lens may be seen as a dark line with the ophthalmoscope, the refraction of the eye will vary according to the point through which it is observed (*i. e.*, through the lens or beyond it), the iris

is tremulous from loosening of the suspensory ligament and lack of the support of the lens, and monocular diplopia and impaired

FIG. 120.



Spontaneous dislocation of lens into the anterior chamber of highly myopic eye. From a patient in the Philadelphia Hospital.

or absent power of accommodation are demonstrable. If there is complete posterior luxation the symptoms are much the same as when the lens has been removed by operation, and if the cause of the dislocation is trauma, the symptoms of the injury, *e. g.*, hemorrhage, etc., may be present.

A dislocated lens usually becomes cataractous, and often causes intense pain and frequent attacks of iritis, or by occluding the angle of the anterior chamber may give rise to glaucoma.

TREATMENT.—In partial dislocation an attempt should be made to secure the best vision with suitable glasses.

In complete luxation into the anterior chamber the lens may be removed by a simple corneal incision. For removal of a lens dislocated into the vitreous humor, provided it is producing irritation, a scoop introduced through a peripheral corneal incision may be employed, or the operation devised by the late C. R. Agnew may be attempted. In the latter, a double needle or "bident" is thrust into the vitreous humor far enough back to avoid wounding the iris, the handle of the instrument is

depressed, the lens is caught and brought forward through the pupil into the anterior chamber, and removed in the ordinary way. If the lens has been dislocated beneath the conjunctiva it should be extracted through a small incision made directly over it.

After the successful removal of a dislocated lens the eye should be provided with cataract-glasses.

CHAPTER XIV.

DISEASES OF THE VITREOUS.

Hyalitis.—Under the general term *hyalitis*, provided this is understood to refer to the vitreous humor and not to its sheath (the hyaloid), may be included the two types of inflammation of this body—the one connected with *suppuration*, and the other with the *formation of opacities*. Under almost all circumstances the hyalitis arises in consequence of diseases of the uveal tract, retina, optic nerve, or from injury.

Purulent Inflammation of the Vitreous (*Suppurative Hyalitis*).—This condition is caused by a penetrating injury, a foreign body, and arises in connection with purulent choroiditis; for instance, as the product of a metastatic choroiditis after inflammation of the cord in newly-born children, or after scarlet fever, erysipelas, relapsing fever, etc.

There is also a good deal of evidence to show that there may be a *spontaneous inflammation* of the vitreous which may manifest itself simply by opacity, or go on to suppuration. Pus in the vitreous may be due to exhaustion and debility consequent upon low fevers, or, in general, the infectious blood diseases. Suppurative hyalitis may start from operation scars from a few months to seven years after healing. The inflammation is of microbic origin.

Symptoms.—If the cornea is clear, a yellowish reflex is seen shining through the pupillary space, there is retraction of the periphery of the iris, and bulging of its pupillary border. Usually, one or two synechiæ are present, and the tension is diminished. In addition to this there may be a pericorneal zone of congestion connected with the inflammation of the iris and ciliary body.

When the pus in the vitreous is circumscribed, the symptoms at the first glance are not unlike those of glioma of the retina, and the name *pseudo-glioma* has been given to this condition,

especially as it is seen in children. It is, however, to be distinguished from a true glioma of the retina by the history of the case, the usual presence of the signs of iritis, the retraction of the periphery and bulging of the pupillary border of the iris, and the diminished tension of the globe.

TREATMENT.—If pus has once formed in the vitreous, in the manner just described, no medicinal treatment is of avail; the ball will go on to shrinking, and enucleation is demanded.

If, during the earlier stages of this affection—for instance, during the course of a low fever—attention is called to the eye and the discovery is made that fine flakes of opacity are beginning to appear in the vitreous, it is quite possible that a vigorous supporting treatment may save the eye from destruction. (Hansell.) The fact of the possibility of the occurrence of such a condition during low fevers, should lead the physician to frequent investigation of the eyes.

The second type of inflammation of the vitreous is that which is attended with the formation of opacities, and hence may be described under the most prominent symptom of the disorder:—

Opacities in the Vitreous.—These are either *fixed* or *moving*, and vary considerably in shape, size, and somewhat in color. The opacities may appear in the form of membranes, bands, dots, threads, flakes, and strings; or, finally, the entire vitreous humor may give evidence of uniform loss of translucency, which on careful focusing resolves itself into a diffuse, dust-like opacity.

The fixed membranous opacities are usually adherent by two or more points to the choroid, retina, optic disc, and sometimes to the ciliary processes, and even to the posterior capsule of the lens. They may exist as a membrane which crosses the vitreous and covers the optic disc, or as membranous bands running from before backwards, and may be coarse, dense, and organized, or fine and more like a cobweb in texture.

Method of Detection.—The examination of the vitreous is made after the manner described on page 105.

The rapidity with which the bodies move depends upon the consistency of the vitreous humor; if this is natural, the movement is slow; if it is fluid or semi-fluid, the movement is correspondingly rapid. The excursion made by opacities in the vit-

reous humor has been compared by Mr. Nettleship to the movement of solid particles and films in a bottle filled with liquid after the bottle has been shaken.

Vitreous opacities move in the direction opposite to that which the eye takes—that is, if the eye is turned upward, the opacity moves downward—while an opacity on the cornea, or in the lens, moves with the movements of the eye. Moreover, an opacity of the vitreous does not at once come to rest when the eye stops moving, but slowly settles; while one situated upon the cornea or the lens ceases its movement as soon as the eye stops. (Compare with page 105.) Finally, any opacity upon the cornea, or even upon the lens, can be excluded by the use of oblique illumination (page 62).

The different layers of the vitreous may be examined for fixed opacities by means of the upright image in the ordinary way, by first finding the optic papilla, then gradually placing stronger and stronger convex lenses behind the sight-hole of the mirror until a + 16 D is in place, thus bringing everything into focus from behind forward. The observer's head must be close to the observed eye. In the same way Knapp has proposed to make use of the inverted image, gradually removing the convex lens from the eye and bringing into view the parts from behind forward until those which are anteriorly situated are in focus.

The *subjective* symptoms of vitreous opacity depend entirely upon their amount and density. There may be little or no depreciation of central vision, or this may be cut down and even entirely obliterated. Patients frequently complain of black and gray spots before their eyes; sometimes these assume fantastic shapes, and not infrequently these shapes repeat themselves so constantly that the patient is able accurately to describe them or even to draw them. The same symptoms may appear where there is no organic disease (page 410). Changes in the field of vision, pain, redness of the eye, or similar conditions will depend largely upon associated changes, and usually are absent if the vitreous alone is affected.

Causes.—(1) *Refractive Error*, probably almost exclusively high degrees of myopia associated with changes in the choroid and the formation of a posterior staphyloma.

(2) *Diseases of the Eye*, chiefly cyclitis, irido-cyclitis, choroiditis and retinitis.

The shape and character of the opacities vary with the condition which has caused them. In cyclitis and irido-cyclitis inflammatory opacities are seen; in chronic and old-standing choroiditis flake-like or thread-like opacities are very common, especially in elderly people, and are probably due to hemorrhages having their origin in the choroid. In syphilitic choroiditis and retinitis, in addition to large, floating opacities, there may be a diffuse mist which resolves itself into the so-called *dust-like opacities*, and is almost characteristic of the disease which has caused the original inflammation of the choroid and retina. The situation of these dust-like opacities is either diffuse through the entire vitreous chamber, or in its posterior layers, or anteriorly, in the neighborhood of the ciliary region.

(3) *Injuries of the Eye*, which have caused a hemorrhage from the choroid or ciliary region. The origin of the opacity is an extravasation of blood. In the latter case, as has already been mentioned, suppuration of the vitreous is likely to occur.

(4) *Diseased Conditions of the System, Local or General.*—Exhaustion of infectious blood diseases or low fevers, wide-spread endarteritis, gout, syphilis, malaria, portal congestion, constipation, anæmia, and irregular or suppressed menstruation cause vitreous opacities. In a few instances vitreous opacities appear to be due to the prolonged action of drugs; for example, arsenic. (Hutchinson.)

(5) *Absence of Apparent Cause.*—Opacities of various shapes, often fine and thread-like, and commonly seen in old people, occur without evident disease of the uveal tract, retina, or optic nerve. Their presence in some instances is without serious import.

It will be seen from what has been said that the origin of vitreous opacities is from various morbid processes, and they may represent the result of an inflammation, a hemorrhage, or a degeneration of the vitreous cells or its constituent parts; that in most instances the opacities are secondary to changes in other portions of the eye; but that in a few instances, both with and without suppuration, a primary inflammation may start in the vitreous body itself.

Prognosis.—This depends entirely upon the cause of the vitreous disease. If this has started in a purulent disease of the choroid, or a purulent change in the vitreous has taken place, the prognosis is exceedingly bad and the eye goes on to destruction.

If the cause of the disease is syphilis or other constitutional condition amenable to treatment, satisfactory clearing of the vitreous may be expected; even very dense opacities will disappear under proper treatment. When the opacities are due to hemorrhage the absorption of the clot is not so likely to take place. Both hemorrhagic opacities and others are subject to relapses.

Treatment.—In any case of vitreous opacity, provided the general fundus of the eye-ground justifies this, and there is reason to believe that eye-strain in any sense is connected with its cause, suitable lenses should be ordered, but the use of the eyes at close ranges should be discouraged.

In syphilitic vitreous disease the usual remedies are applicable. When the vitreous change depends upon an exhausted condition of the system supportive measures are indicated.

If the patient is in condition to receive this, excellent results follow sweats with pilocarpine or jaborandi. The drug may also be used in small doses not sufficient to produce sweating, and seems to have an alterative effect.

If vitreous disease depends upon constipation and portal congestion, in addition to a regulated diet, cholagogue laxatives should be administered. Anæmia and menstrual irregularities are evident indications for treatment; in the former case the combination of bichloride of mercury with iron is useful. If there is an active inflammatory condition, local blood-letting from the temple should be practised; in fact, the treatment then becomes that of the acute inflammation which has started the disorder. The use of the galvanic current has been warmly recommended by some surgeons in vitreous opacities.

A dense membranous opacity, more or less fixed and general, may be subjected to a needle operation. According to Bull, an ordinary discission needle should be inserted in front of the equator of the eyeball and just below the lower border of the external rectus muscle, and the membrane divided.

Muscæ Volitantes (*Myodesopsia*) are the black specks and motes often seen floating in the field of vision, especially if the eye is directed towards a bright surface. They follow the movements of the eye, and are especially annoying during the act of reading, as they float across the page. They do not interfere with vision.

There is no true opacity of the vitreous, and the ophthalmoscope fails to detect in these instances any floating opaque particles. They are probably due to the shadows thrown upon the retina by naturally-formed elements in the vitreous bodies, perhaps the remains of embryonic tissue.

Although of no serious import, so far as sight is concerned, they produce an amazing amount of annoyance in nervous and sensitive patients. Patients frequently complain that they obscure an object, floating directly in front of it, and assume exaggerated and fantastic shapes. They are often ascribed by the laity to disorders of digestion and torpidity of the liver, and are aggravated by the habit which their possessors form of searching for them.

Treatment.—Any cause of eye-strain should be removed, and a course of alterative tonics may be ordered. In short, in troublesome cases, the treatment is much the same as would be applied to an ordinary instance of asthenopia.

Hemorrhage into the Vitreous.—As has already been stated, many vitreous opacities result from hemorrhages from the vessels of the choroid, ciliary body or retina. Injury is a common cause of hemorrhage in the vitreous, and under such circumstances the entire chamber may be so filled with blood that it is easily detected in its natural color as a dark red clot, sometimes being so dense that no reflex comes from the fundus.

Finally, in certain cases, generally in young male adults, *spontaneous hemorrhage* into the vitreous occurs, together with hemorrhage in the retina. According to Eales such patients are liable to constipation, irregularity of the circulation and epistaxis. Hutchinson thinks that gout may be a cause in some cases. There is marked disturbance of vision depending on the density of the clot, which is likely to be imperfectly absorbed.

Treatment.—This consists in local depletion, cardiac sedatives, ergot, laxatives, and later the administration of small doses

of iodide of potash. As in other vitreous changes, if the general condition permits it, a sweat-cure may be tried, either by means of the Turkish bath or with jaborandi.

Synchisis (*Fluidity of the Vitreous*).—This is a softened or fluid condition of the vitreous, which, as has already been implied, can be positively diagnosticated, or, rather, assumed to be present, only by noticing the rapid movement of particles of opacity contained within it during motions of the eye. Although tremulousness of the iris is sometimes seen when there is decided fluidity of the vitreous humor, this symptom does not prove its condition, but only a lack of support by the crystalline lens owing to relaxation of the zonula. The tension of the eyeball may be diminished.

It occurs in elderly people with disease of the choroid coat, and with staphyloma. A fluid vitreous may be a complicating circumstance in an eye in which an operation is performed; for instance, in a cataract extraction, sometimes causing excessive loss of the vitreous after the corneal incision.

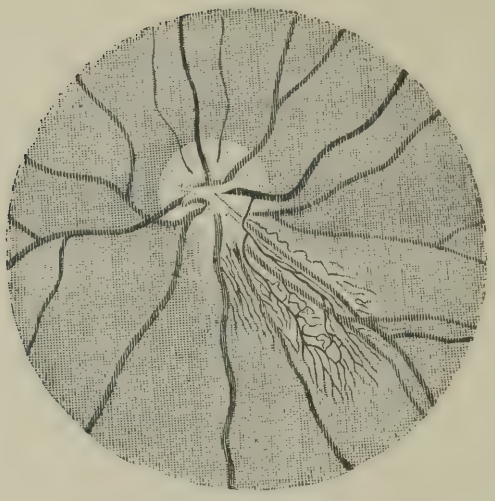
Synchisis Scintillans is a term applied to a fluid vitreous which holds in suspension numerous scales of cholesterin which move with great rapidity across the ophthalmoscopic field and produce a striking picture, resembling a shower of brilliant crystals. Poncet has reported in this connection tyrosin and crystallized phosphates, but recent investigations seem to show that the appearance is due solely to cholesterin.

The affection probably depends upon a choroiditis, and is said to be more common among alcoholic subjects and those with arthritic tendency or any serious disorder of nutrition. The affection is, however, clinically at least, seen in eyes which apparently are not diseased in other portions, especially in old people, and may be present in advanced degree without depreciation of visual acuity.

Treatment.—This does not appear to have any influence. Iron has been recommended. The condition is a distinct contra-indication to operative measures upon the eye.

Bloodvessel-Formation in Vitreous.—Occasionally cases are examined which present an entire new bloodvessel formation in the vitreous in front of the entrance of the optic nerve. (Fig. 121.)

Fig. 121.



Bloodvessels in the vitreous (Hirschberg).

Only a few vessels may be present, or, in extreme cases, the entire disc is obscured by a congeries of contorted vessels, the whole forming an extensive vascular veil of anastomosing capillaries coming directly from the nerve head and having no connection with the retinal vessels (Harlan). The vessels have been supposed to owe their origin to vitreous hemorrhages; in other cases the origin probably is of a specific nature (Hirschberg).

Foreign Bodies in the Vitreous.—These are usually chips of steel, splinters of glass, or small shot. They may reach the vitreous by penetrating the sclera directly, or by passing through the cornea and lens. The foreign body, if unremoved, may cause suppurative hyalitis in the injured eye, or sympathetic ophthalmitis in the fellow eye. The symptoms, diagnosis, and treatment of foreign bodies in the vitreous have been included with injuries of the sclera, on page 305.

Entozoa in the Vitreous.—*Cysticerci* in the vitreous are exceedingly rare, except in Northern Germany.

Another parasite which has been described in the vitreous, at least one instance of its removal being on record, is the *filaria sanguinis hominis.*

Detachment of the Vitreous is a condition which, of itself, would not create blindness; but because it produces detachment of the retina, it is a change of the gravest import.

Traumatism, choroiditis, hemorrhages, intraocular growths, and staphyloma may cause it. The vitreous humor is said to be occasionally detached without change in its translucency, although opacities are usually present.

Persistent Hyaloid Artery.—During fœtal life the vitreous humor is traversed by the *hyaloid artery*, which is an extension of the central artery of the retina, and proceeds from the optic nerve to the posterior surface of the lens. The vessel passes through a channel, having a delicate membranous lining, known as the *canal of Cloquet*. Obliteration of this artery begins at the end of the fifth month of gestation.

Sometimes obliteration fails, and the most important congenital anomaly of the vitreous is evident, namely, the persistence of some vestige of the hyaloid artery. It may appear in the following forms:—

A rudimentary strand attached to the disc; a strand attached to the disc and a vestige also at the posterior surface of the lens; a strand passing from the disc to the lens; a similar strand containing blood; a strand attached to the lens alone; and a persistent canal (canal of Cloquet) without any remnant of the vessel. These are the most ordinary and well-recognized forms.

In addition to this, shreds of tissue and membranes on the optic disc, masses resembling connective tissue, and small cystic bodies are probably remnants of this artery. Its rôle in producing posterior capsular cataract has already been described. The appearances are readily recognized by the ophthalmoscope, and require no further description than the names already given.

This classification has been condensed from the monograph of Dr. De Beck, who has written the most complete account of the anomaly.

CHAPTER XV.

DISEASES OF THE RETINA.

Hyperæmia of the Retina.—This condition, independent of a true inflammation, is not readily demonstrable with the ophthalmoscope.

Although the capillary network of the retina, invisible under ordinary circumstances, may, under other conditions, become evident (*capillary congestion*), the presence of a congestion is inferred, not by any alteration in the appearance of the retina itself, but by changes in the surface of the optic disc, generally known by the terms "*increased redness*" or "*undue capillarity*," and is associated with increase in the amount of the retinal striation which surrounds the papilla, so that its edges are veiled or slightly blurred. Such appearances are common in asthenopic and ametropic eyes, and in people whose occupations expose them to the glare of artificial heat, *e. g.*, puddlers.

It is possible to speak with more confidence of a change in the calibre, course, color, and general size of the retinal vessels, or, in other words, of a hyperæmia of the central system. Under these circumstances more than the normal amount of blood finds its way into these vessels, which consequently are distended, tortuous, or positively lengthened. Gowers divides hyperæmia into an *active* type, when the increased amount of blood is sent to the retina because the systemic circulation is unduly filled, *e. g.*, in rapid action of the heart with fever, pneumonia, etc.; and a *passive* type, when there is failure of the blood to be returned from the eye, for example, in compression of the retinal vein. Then the veins are large, filled with dark blood, and often tortuous, while the arteries are unaffected, or are smaller than usual.

Among the *general causes* of a stasis hyperæmia may be mentioned mitral disease, emphysema, violent cough, convulsive seizures, or, in short, any cause which is likely to produce engorge-

ment of the veins of the head and neck, and to prevent the emptying of their contents into the great venous channels of the chest. Increase in the diameter of the veins is much more frequent than increase in the diameter of the arteries, while, on the other hand, increase in the diameter of the arteries is uncommon as compared with a diminution of their calibre. (Loring.) Pathological significance must not be ascribed to apparent changes in the diameter of the veins, because eye-grounds are often crossed by large dark veins, the arteries being small by contrast, without definite, local or general cause for the phenomenon.

Ordinarily patients with hyperæmia of the retina do not complain of characteristic symptoms, but when this condition is connected with ametropia there are ocular pain, photophobia and lack of eye-endurance.

Treatment.—In hyperæmia dependent upon refractive asthenopia, the evident treatment is physiological rest under the influence of atropine, and later a suitable correction with glasses. If severe, blood may be abstracted from the temples, or dry cupping may be employed, and internally, bromide of lithium or soda, with or without ergot, acts well. When the condition depends upon general causes, these furnish the indications for treatment.

Anæmia of the Retina should be looked upon not as a disorder of this structure, but as a symptom of local pressure, or of some cause situated within the general economy.

The highest type of anæmia of the retinal vessels is seen with stoppage of the circulation by an embolus, and occurs in marked degree as the result of compression, in consecutive atrophy of the optic nerve. Other causes of anæmia of the retina are general anæmia, cerebral anæmia, and syncope.

Extreme narrowing of the retinal arteries is occasionally seen as the result of a vaso-motor spasm; for example in "sick headaches," and in true migraine. In these cases there may be temporary complete or partial (hemianopic) blindness. If the blindness approaches from above downwards the obstruction is in the retinal circulation, but if it assumes a lateral form, the cortical visual centres are probably affected. (Priestley Smith.) Impeded retinal circulation may be attributed to the high arterial tension which is known to be present in some cases of migraine.

Under the name *ischæmia of the retinæ* a condition is described in which, with complete blindness, there is pallor of the optic discs and extreme narrowing of the retinal bloodvessels. This has been seen in the collapse-stage of cholera (Graefe), in whooping-cough (Knapp, Noyes), in erysipelas (Ayres), and under the influence of toxic doses of quinine.

Treatment.—The flagging circulation should be stimulated by digitalis and strychnia. Nitrite of amyl has been employed in spasm of the retinal arteries. General anæmia calls for its appropriate remedies.

Hyperæsthesia of the Retina.—This is characterized chiefly by the *symptoms* which indicate a supersensitive state of the retina—dread of light, lachrymation, blepharospasm, neuralgic pain and imperfect eye-endurance.

Ophthalmoscopic changes may be practically absent, but in most instances those lesions will be detected which have been referred to under *congestion*, but which, adopting a name originally employed by Jaeger and used by Loring, may be described as *irritation of the retina*. These are: undue redness of the nerve-head, veiling of its nasal edges, from which, and from those above and below, distinct striation of the retinal fibres are evident, while streaks of light tissue can be followed along the course of the larger vessels. The margins of the disc are veiled by this retinal striation, and although the physiological cup, if present, or the "light spot," may be unchanged, the general surface of the disc seems to be covered by a delicate layer of œdematous tissue. At the same time the choroid reveals changes similar to those described on page 344, or else is distinctly granular and macerated. Often the entire fundus fails to present a distinct ophthalmoscopic picture, and may be described by saying that the details of the eye-ground are not sharply seen by the aid of any correcting glass.

Causes.—Hyperæsthesia and irritation of the retina are found in neurotic and hysterical subjects, and may or may not be associated with errors of refraction. They are also seen with chronic headache, neuralgia, and after prolonged fevers and pulmonary disorders. In a series of cases which the author has reported, oxaluria appeared to be the source of the trouble.

In some instances of retinal irritation the cause seems to be dependent upon changes in the naso-pharynx; for example, engorgement of the septum, associated with myxomatous and hypersensitive spots, vaso-paretic and infiltrated turbinals, and secondary changes in the pharynx and larynx. Just as areas of hyperæsthesia in these regions may be part of a general neurosis, so, also, they may be both directly and indirectly connected with a hyperæsthetic condition of the retina, and the eyes will not grow comfortable until the nasal disease is cured. It is probable that retinal irritation may sometimes be the forerunner of organic change in the optic nerve. (Loring.)

Treatment.—It is important to remember that glasses are not a panacea, and that even if slight errors of refraction exist in these cases, their correction alone does not suffice to relieve the symptoms. General tonics, rest, massage, and all measures calculated to overcome debility or existing neurosis are required. Although strychnia is usually indicated by the general conditions, it may aggravate an irritable retina precisely as it does irritations of nervous tissue elsewhere. The naso-pharynx should be explored and abnormal conditions corrected.

Anæsthesia of the Retina (*Neurasthenic Asthenopia*), like several other disorders of the retina, just considered, should be regarded not as an affection peculiar to the eye, but as one of the symptoms of a very complicated neurosis. Very often the condition described in the preceding paragraph and the present affection are closely allied, and with neurasthenic asthenopia there may be marked hyperæsthesia and irritation of the retina. On the other hand such appearances may be entirely absent.

The *subjective symptoms* of this condition have been arranged by Wilbrand as follows: Peculiar contraction of the field of vision; rapid disappearance from view of any object which is being fixed; diminution of central vision; sudden attacks of obscuration of vision and processions of scotomas; visual hallucinations; lack of fixation of the optical memory-images; inability to read for any length of time; weariness on the part of the muscles both of the eyes and the eyelids; and positive insufficiency of the internal recti. In addition to this there may be

defective accommodation, intolerance of light, and improvement of vision in the dusk or through tinted glasses.

The most characteristic symptom of the affection is a peculiar contraction of the field of vision, which at the beginning of the examination may present normal limits, but as the examiner proceeds, contracts most markedly both above and below the horizontal meridian, because the nervous apparatus becomes fatigued. If the patient is allowed to rest, and the examination is repeated, but the test-object is now moved along the meridians in the opposite direction from that in which it was moved in the first examination, a second field will be obtained, which is called by Wilbrand the *counter-field*. The most contracted part of this counter-field lies on the same side as the most expanded part of the previous visual field. The visual field for colors exhibits about the same conditions as that for white. This is not only characteristic of retinal anæsthesia, but of the retinal exhaustion which is found in a variety of conditions.

Patients affected with this condition are for the most part women, often the subjects of ovarian and uterine disease, hysteria and chlorosis. It is not an uncommon affection about the time of puberty. Although by far the most of its subjects are found in the feminine sex, pure types are also seen in men.

In addition to the local symptoms described in connection with the visual organ, these patients have a host of general disturbances indicative of their defective nutrition and nervous tone. In short, they complain of that series of symptoms which has been classified under the much-abused term neurasthenia, or increased excitability of the nervous system, with a tendency to rapid fatigue.

Treatment.—This is directed largely towards the general condition, and includes in the most advanced types all that is meant by the term "rest-cure," namely, rest with seclusion, forced feeding, massage, and electricity. Tonics of various kinds are indicated, and ascending doses of nux vomica and strychnia are especially valuable, provided the retinas are not distinctly congested. Under proper circumstances, other cases are suitably treated by graduated exercise.

Although tinted glasses are recommended, they are not always advisable lest the affected eyes becomes too much accustomed to the dull light afforded through such protection. Any error of refraction should be corrected, but spectacles of all types, and all treatment directed towards the ocular muscles, are not alone sufficient to cure these cases—cases, moreover, which are constantly subject to a relapse of their symptoms.

Retinitis.—Under the general term *retinitis* are included the various types of inflammation of the retina.

Varieties.—Retinitis may be *primary*, owing to constitutional causes and altered states of the blood and bloodvessels; or *secondary*, owing to extension from an inflamed iris, ciliary body, or choroid. It is further divided, according to its character, into *circumscribed* and *diffuse* retinitis; according to its pathological nature, into *serous* and *parenchymatous* retinitis; and according to its supposed etiology, into the various clinical types presently to be described.

Symptoms.—Certain *objective* and *subjective* symptoms are present in most of the forms of retinitis.

(1) *Loss in the Transparency of the Retina.*—This is the only characteristic ophthalmoscopic symptom of retinitis. It may be a faint diffuse haze, a circumscribed opacity and swelling, or streaks of white infiltration, especially along the lines of the larger vessels.

(2) *Areas of Exudation.*—These are an advanced process of the condition just described. They appear as white spots, sometimes discrete, sometimes confluent, or as patches of bluish-gray, buff, or yellowish color. They should be differentiated from the shining, white plaques due to atrophy of the choroid by their softer tone, their situation, and because there is an absence of accumulation of choroidal pigment. They may be present anywhere in the retina, or localized in the macular region.

(3) *Tortuosity of the Vessels and Change in their Calibre.*—The veins are darker than normal, unduly wavy in outline, or positively lengthened in their course. The arteries may not be materially changed, but the finer transverse branches are often very tortuous, and both sets of vessels are liable to dis-

placement from their normal level as they cross areas of thickening, or to partial obscuration by the puffy and infiltrated retina. Many vessels invisible in health become injected in retinitis, and form a fine red striation, passing from the nerve-head. Pulsation of the vessels is readily induced by pressure.

(4) *Hemorrhages.*—These occur either in the fibre-layer or the deeper portions of the retina. The presence of retinal hemorrhage alone, however, does not indicate the existence of inflammation, as it may occur quite independently of retinitis.

When the hemorrhage is placed in the superficial or nerve-fibre layer, it usually assumes a *flame-shape*, with frayed or feathery edges; when its situation is in the deeper layer, it has a cleaner-cut border and more rounded shape.

(5) *Changes in the Nerve-head.*—More or less change in the optic papilla is present: undue redness, loss of the distinctness of its margins, obscuration by the swollen and puffy retinal fibres, or finally positive inflammation or neuritis. Atrophy of the disc is commonly present after severe retinitis.

(6) *Pigmentation.*—Black spots of pigment mark the situation of former retinal hemorrhages. Pigment in the retina, like hemorrhages, although in many instances a sequence of retinitis, is of itself not necessarily a symptom of inflammation of this membrane.

The difference between pigment in the retina and in the choroid has been described on page 346.

(7) *Atrophy of the Retina.*—This, like atrophy of the choroid, may indicate a former hemorrhage, or an area of inflammation. All of the retinal layers, as well as the choroid, may be involved, exposing a white patch of sclera (*atrophic choroido-retinitis*), or only the superficial layers may be affected, and the spot may be marked by a permanent whitish or yellowish opacity. Contraction of the vessels and white tissue along their coats are often seen after retinitis.

In addition to the ophthalmoscopic signs there are:—

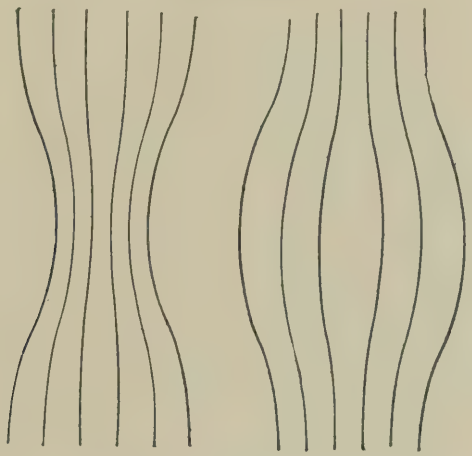
(1) *Change in Visual Acuity.*—Central vision is *diminished* in direct proportion to the severity of the case and the situation of the inflammatory action. In the early stages of simple retinitis

there may be *increased* visual acuity, although this is more common with retinal irritation than with inflammation.

(2) *Change in the Field of Vision.*—This may be irregularly or concentrically contracted, or scotomata may appear in its centre.

(3) *Distortion of Vision.*—This occurs under two forms: (*a*) Objects appear to be reduced in size (*micropsia*); (*b*) objects appear to undergo change in their contour or shape (*metamorphopsia*). Vertically-placed parallel lines, on the one hand, appear to be bulged outward, and on the other to be bent inward. Fine parallel lines may appear *wavy* to a normal eye.

Fig. 122.



Distortion of vertically-placed parallel lines in retinitis (Loring).

(4) *Pain and Photophobia.*—Acute pain is almost always absent even in violent forms of retinal inflammation; indeed, it is much more likely to be present in the less pronounced grades. Usually the sensation is one of discomfort rather than of actual pain. Photophobia may or may not be present. It is never a marked sign, although comfort ensues from the use of tinted glasses.

Diagnosis.—The diagnosis of retinitis depends upon the essential symptom of the disease—opacity or loss of transparency in the retina. All the other symptoms which may be present—

exudation, hemorrhages, pigmentation, and atrophy—help to make up the clinical characteristics of the various types, but in themselves are not diagnostic of inflammation of this membrane.

Much diagnostic aid is obtained by noting the effect of the disease upon vision, especially under the influence of diminished illumination, and when acuity of sight fails quite out of proportion to the amount of the light reduction, the student should at once be upon his guard. If the coarse changes detailed in the general symptom-grouping are present, the picture is readily interpreted.

Course, Complications and Prognosis.—The course of a retinitis, like any other inflammation, may be *acute* or *chronic*, and its progress of long or short duration. When the retina and choroid are simultaneously inflamed, a common complication is change in the vitreous (*vitreous opacities*), and an almost constant association is inflammation of the optic papilla, leading to atrophy in prolonged cases (*retinitic atrophy*).

The *prognosis* may be either favorable, grave, or positively fatal, depending upon the extent of the inflammation, its situation in the inner or outer layers of the retina, and the cause. Before giving a prognosis, the surgeon must always attempt to estimate the extent of the permanent disability which is likely to remain in the form of atrophy of the membrane, or secondary changes in the papilla. Other things being equal, the prognosis of syphilitic retinitis is the most favorable.

Treatment.—This, in general terms, demands perfect rest for the inflamed organ. In sthenic cases, in the early stages, blood-letting from the temple is indicated.

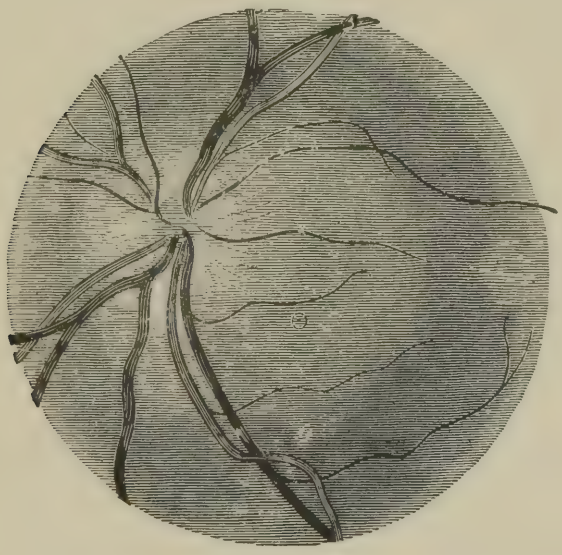
The remedies most likely to afford relief are the various forms of mercury, iodide and bromide of potash, ergot, and occasionally jaborandi and Turkish baths. Special methods of treatment are reserved for the sections devoted to the several clinical varieties.

Serous Retinitis (*Retinitis simplex, Diffuse Retinitis, Œdema of the Retina*). This disease is characterized by an infiltration, especially of the nerve-fibre and ganglionic layer of the retina, causing opacity and œdema, together with hyperæmia, most marked in the veins.

The opacity varies from a delicate veiling to a decided gray-

white opacity, most noticeable around the nerve-head, the margins of which are veiled or hidden. From this point, the grayish opacity shades out into the surrounding retina. The disc is not swollen, it is simply hidden by the œdematous infiltration, or, if the œdema is not marked, it is very red and its margins obscured by the radiation of finely-injected capillaries from its margins. The veins are dark, fuller than normal, tortuous, and often partly covered by the swollen tissue; the arteries are not much changed in size, unless perchance they may be reduced in calibre by compression. Hemorrhages are rare, and exudations in the macular region are uncommon.

Fig. 123.



Serous retinitis (Meyer).

There are no external signs of this form of inflammation. Both direct and indirect vision are affected, the former being "foggy;" the latter concentrically contracted.

Cause.—Independently of the fact that it may be the initial change of other forms presently to be described, this type has been ascribed to cold, to exposure, to undue light and heat,

and to the influence of refractive error in eyes worked under the disadvantage of imperfect illumination. In other cases it is quite impossible to assign a reason for its development.

Treatment.—This is conducted on the general principles already laid down.

Parenchymatous Retinitis.—By this term is understood those forms of retinitis in which, in addition to œdematous infiltration, opacity of the retina and venous hyperæmia, there is pronounced cellular infiltration and structural change leading finally to atrophy of the elements.

Exudations of yellowish or gray color are visible, occurring in patches throughout the eye-ground, and often localized in a characteristic manner in the macula. Small hemorrhages are commonly present, and the morbid processes may attack the sheaths of the vessels, causing thickening and hypertrophy.

There are no diagnostic external manifestations. Deeply seated pain of a dull, aching character may be present. Vision is often much disturbed, varying from a mere fogginess in the outlines of objects to an almost absolute loss of sight. Contraction of the field of vision and positive scotomata are demonstrable, and the phenomena of distortion of objects are apparent. The disease may be circumscribed or diffuse, and localized in the external or internal layers, or affect both of these and also involve the choroid.

Prognosis.—This is always grave, and although in certain cases absorption of the products is possible, compression and atrophy of the nervous elements must result in most instances.

Cause.—The various constitutional complaints, disturbances of the uterine functions, and intracranial disorders, are the most prominent causes.

Treatment is governed by the probable exciting cause, together with proper rest for the eyes.

Partaking of the nature of one or the other of these forms there are certain clinical types :—

Syphilitic Retinitis.—The syphilitic forms of retinal inflammation have been divided by Alexander into (a) *choroido-retinitis;* (b) *simple syphilitic retinitis;* (c) *retinitis with exudations;* (d) *retinitis with hemorrhages;* and (e) *central relapsing retinitis.*

The *first form* is really a disease of the choroid, and the patho-

logical changes of cellular infiltration, exudation, atrophy, and proliferation of the pigment epithelium are found in the choroid, between the choroid and retina, and in the adjacent retinal layers.

The following signs are visible: Opacity of the vitreous, especially in the posterior portion, which resolves itself into fine points or dust-like particles, and stretches out to the periphery like a cloud; loss of transparency of the retina surrounding the nerve-head which may be unduly hyperæmic, and on account of the fine opacity in the vitreous, may give the impression that it is swollen; numerous yellowish or white spots of exudation bounded by pigment beneath the vessels of the retina in the periphery of the eye-grounds, and white spots in the macula; and, finally, occasional participation of the iris and posterior layer of the cornea.

The *subjective* symptoms are: Depreciation of central vision, very marked in the later stages; night blindness and great lessening of visual acuity under weak illumination; irregular and concentric contraction of the visual field and the formation of ring scotomata as well as positive scotomata in the centre of the field; and shimmerings, dancing spots and circles (photopsies), and distortion of objects in the form of micropsia and metamorphopsia due to separation of the rods and cones by the effusion.

In the *second form* there appears to be a localization of the disease in the retina, and the ophthalmoscope reveals a gray opacity surrounding the nerve-entrance, this opacity stretching out in lines along the vessels; the papilla is discolored, cloudy, and has been compared to a yellowish-red, oval body seen through a covering of fog. The veins are darker than normal, the arteries usually are not materially changed.

Other objective symptoms are floating vitreous opacities, exudations along the lines of the vessels (*retinitis with exudations*), and extravasations of blood, usually round in shape, attributed to disease of the vessel walls (endarteritis), or to the formation of thrombi (*retinitis with hemorrhage*). Hemorrhages in syphilitic retinitis, however, are of rare occurrence.

Date of Occurrence.—Diffuse syphilitic retinitis may occur in congenital and acquired syphilis. In the acquired form of the

disease it appears from one to two years after infection, sometimes as early as the sixth month, and is found in about eight per cent. of the cases (Alexander). One eye alone may be affected, but usually after several months the second eye is also involved.

True retinitis must not be confounded with the so-called "retinal irritation" commonly seen in association with iritis, and the symptoms of which have been described under hyperæmia.

Course and Prognosis.—Although the onset of syphilitic retinitis may be sudden, the course is essentially chronic.

The *prognosis* largely depends upon the stage at which treatment is begun and the vigor of the measures employed. Delayed or neglected treatment may lead to the grave consequences of extensive choroiditis, pigmentary degeneration in the retina, and atrophy of the optic disc. Even under favorable circumstances improvement may be temporary and many stubborn relapses occur.

Treatment.—The same constitutional measures recommended in the treatment of syphilitic iritis are applicable. Bleeding from the temple has been recommended, but it is difficult to understand upon what grounds.

Central Relapsing Retinitis (*Retinitis macularis*) is the *last form* of syphilitic retinitis which requires mention. It belongs to the late manifestations of syphilis, and appears in the form of a gray or yellow area in the macula, or as numerous small, yellow, or yellowish-white spots and pigment dots, or as a diffuse opacity of this region. The papilla and its surroundings are unaffected. A characteristic of the disease is its frequent relapses. It is a rare form of syphilitic retinitis, and stubborn in its character.

Purulent Retinitis (*Septic Retinitis*).—This term has been applied to an affection seen in pyæmia, puerperal septicæmia, putrid bronchitis, and other pyogenic conditions, and is characterized by small, circumscribed white spots near the papilla and in the macular region. Usually both eyes are involved, and numerous small hemorrhages may be seen. These spots are due to fatty degeneration of the capillaries and infiltration of the retinal fibres, and have been attributed to a change in the composition of the blood and to emboli of bacteria.

Suppurative choroiditis, described on page 354, may begin in the retina with plugging of the vessels, opacity of the layers and hemorrhages, and under such circumstances may be looked upon as the violent form of purulent retinitis, or, as it is sometimes called, *embolic panophthalmitis*. Unlike the first variety described, a single eye is commonly affected, although both may suffer. As Loring suggests, the more frequent use of the ophthalmoscope during septicæmic conditions would probably disclose the earlier symptoms of this affection, before the vitreous becomes filled with pus, rendering a view of the fundus impossible.

Anatomical investigations have shown that an independent or *primary purulent retinitis* may occur in an *acute* form from a penetrating foreign body, and in a *chronic* form, presenting the clinical picture of suppurative choroiditis.

Treatment.—In the severe forms which pass into a general ophthalmitis, treatment is practically of no avail; indeed, in pyæmic conditions, these are a precursor of death. In the milder forms, the prognosis is not so unfavorable, and recovery from the causative disease may take place.

Hemorrhagic Retinitis.—Although the mere presence of hemorrhages in the retina does not necessarily mean the coexistence of retinitis, if signs of inflammation are added, the term hemorrhagic retinitis is suitable.

In a typical case, the appearances are as follows: Swelling of the papilla, its edges being clouded or hidden by an opaque infiltration of the surrounding retina; darkly tortuous and distended veins, but small arteries; and numerous hemorrhages, either linear, flame-shaped, or, when lying in the deeper layers, irregular and round in appearance.

The size, number, diffusion and localization of the hemorrhages vary. Thus, they may be everywhere throughout the eye-ground, or grouped especially in the macular region, or around the papilla. If white spots are present as the result of degeneration after absorption of the blood, the appearances may closely resemble those seen in so-called renal retinitis, which, indeed, may be one of the types of hemorrhagic retinitis.

Causes.—Hemorrhagic retinitis occurs with diseases of the heart and of the bloodvessels, *e. g.*, hypertrophy, aneurism, and

endarteritis; in suppressed menstruation; at the climacteric; and in a variety of general and local diseases, sometimes presenting types presently to be described under special clinical designations. More rarely, retinitis with hemorrhages is caused by secondary syphilis.

The hemorrhage in most instances is due to rupture of small vessels, whose coats have become degenerated; in other cases, it has been ascribed to diapedesis of the blood corpuscles. The disease is usually monocular. No doubt in many cases the presence of the hemorrhages determines the retinitis by causing irritation of the retinal fibres, and in this sense, both the extravasation and the inflammation are symptoms of the vascular disease, which is the primary affection.

Prognosis.—This is unfavorable, both as to sight and because the ocular condition may indicate a grave vascular or cardiac malady, and may be the forerunner of extravasations in vital centres. Secondary changes in the retina and optic nerve are likely to follow; sometimes glaucoma results.

Treatment.—In addition to local depletion from the temple and protecting the eye with dark glasses, the therapeutic measures must be governed by the general condition. Often iodide of potash is indicated, with or without cardiac sedatives. Ergot has been recommended, and also small, not diaphoretic, doses of pilocarpine. Any congestion of the portal circulation, which in itself may originate the disorder, should be regulated by suitable laxatives.

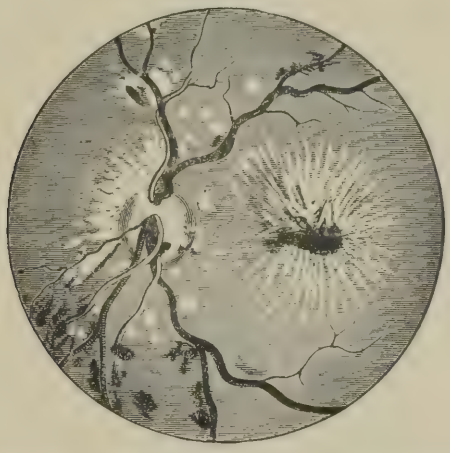
Albuminuric Retinitis (*Renal retinitis, Papillo-retinitis, Retinitis of Bright's disease*).

Symptoms.—In a typical case, beginning in the macula or its immediate neighborhood, and continuing to be most numerous in this region, variously shaped and placed white spots appear. These at first may be small, discrete, and sharply separated, but later, or under other conditions, they form a somewhat star-shaped figure, the rays of which surround the fovea, but for the most part do not involve it. Occasionally, instead of a stellate arrangement, the white spots and lines, somewhat radially placed like spokes in a wheel, affect this neighborhood in part, but do not completely encircle it.

At some distance from the papilla, and often surrounding it, larger yellowish-white or white spots are seen, which may coalesce and form a ring-shaped zone around the nerve-head, broader than its own diameter. This striking, wide, white area has been compared to snow, and designated "the snow bank appearance of the retina."

The fine white spots in the macula are due to fatty infiltration of the inner ends of the supporting fibres (Mueller's fibres), and

Fig. 124.



Albuminuric retinitis (Wecker and Masselon). The white spots represent areas of fatty degeneration; the dark spots, hemorrhages. A somewhat star-shaped figure occupies the macula.

in general terms, the white spots are caused by fatty degeneration of the fibre and granular layers of the retina, round cell infiltration, and varicose hypertrophy of the nerve fibres.

Another feature, but unlike the white spots having no pathognomic appearances, are the *hemorrhages*. They may be linear, flame-shaped, or round, or mere flecks scattered here and there, and found with difficulty, or they constitute large, dark-red extravasations. Moreover, they are not constant, like the white spots, but at times disappear, leaving white marks which denote their former situation. Sometimes they occur in great numbers, like fresh explosions. To a certain extent, they are indications of the violence of the disease.

The bloodvessels may run over the white plaques, or may be buried in the swollen retina. Sometimes a vessel disappears beneath the infiltration, to reappear at some distance beyond. The veins are dark and often tortuous; the arteries, as in other forms of retinitis, are not materially altered in size. In the later stages the vessels exhibit lack of transparency of their walls, in the form of white tissue along the sheaths, or they are actually converted into white strings.

Finally, the optic papilla and its immediate surroundings, may partake of the nature of an *intense hyperæmia*, or a swelling of the nerve-head occurs, quite indistinguishable from that of *optic neuritis*, as it is seen in tumor of the brain. Under any circumstances, the edge of the papilla is clouded, but not necessarily swollen, the surrounding retina finely clouded, and traversed with numerous radiating injected lines, like those described in other types of retinitis. Quite commonly the changes in the papilla directly join the band of fatty infiltration, already described, surrounding the end of the optic nerve.

The chief, in fact the only, *subjective* symptom is depreciation of vision, which may vary from a slight and gradual impairment to complete blindness. It is a well-known fact that Bright's disease is often discovered by an ophthalmoscopic examination, the patient being ignorant of the fact that he is the subject of serious organic malady.

Forms of the Disease.—Two varieties have been recognized—an *inflammatory* and a *degenerative* type. Often the two are combined.

The former may be present as violent *neuro-retinitis* from the beginning, or it may start as a degenerative type, and assume inflammatory action. The latter begins without inflammatory changes, the white spots are small, often quite minute, and separated by comparatively normal areas, and the hemorrhages, if present, are inconspicuous, being confined largely to the nerve-fibre layer. If hemorrhages are the most conspicuous feature of the disease, the term *hemorrhagic* is applied; if the changes are almost wholly confined to the optic papilla, the *neuritic* type is developed.

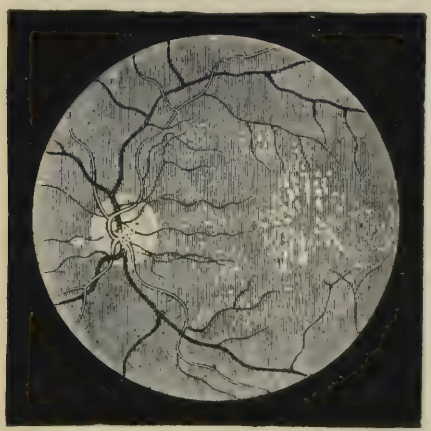
It is probable that in some instances single small hemorrhages and comparatively insignificant dots in the macula may be the

signs of renal retinitis, and consequently of renal disease. In every case of retinal disease the urine should be frequently and thoroughly examined.

Causes.—While in general terms, so-called Bright's disease is the cause of the retinitis which bears its name, it most frequently occurs with the type in which the chronic granular kidney is the chief lesion. It may also arise with large white kidney, and with lardaceous disease, but is rare in the latter. The retinitis seen with pregnancy is most commonly due to albuminuria, and the disorder is also found with scarlatinal nephritis. In a few cases functional albuminuria causes retinal changes. Almost invariably both eyes are involved, but in rare instances the affection has been monocular. The author has observed one such case, which, however, was not examined *post mortem*.

Course, Complications and Prognosis.—The course of typical renal retinitis has been divided into the stage of hyper-

Fig. 125.



Albuminuric retinitis in a late stage. The white dots represent the spots of fatty change, and are most numerous in the macula (Wecker and Jaeger).

æmia of the papilla, opacity of the retina and hemorrhages; the stage of fatty degeneration; and the stage of retrograde metamorphosis and atrophy.

The white spots may subside, but rarely disappear entirely, the macular changes being most permanent. (Fig. 125.) Discoloration and atrophy of the papilla, contraction of the vessels and the formation of white tissue along their walls, and pigment changes in the retina finally result.

Detachment of the retina, hemorrhage into the vitreous, embolism and thrombosis of the vessels, extravasations into the choroid, and rarely glaucoma, have been described as complications of this affection.

The *prognosis*, as far as vision is concerned, is most unfavorable, except in the mildest forms, not only on account of the sequential changes, but also because of the direct involvement of the macula. In so far as the life of the patient is concerned, albuminuric retinitis is a most unfavorable symptom, and the large majority of the patients die within two years after its appearance, prolongation of life to the end of five years being exceedingly rare.

In the albuminuric retinitis of pregnancy the prognosis in regard to vision and the life of the patient depends upon the duration of gestation. With the termination of pregnancy the inflammatory deposits (the type most often is inflammatory) may subside, and good vision may be restored, provided the process has not continued so long that the secondary changes already described have taken place. For this reason the induction of premature labor has been recommended as a therapeutic measure.

Diagnosis.—In widespread cases of albuminuric retinitis, the changes detailed in the symptom-grouping are quite characteristic, and may be said to be pathognomonic of kidney disease.

Neuro-retinitis from intracranial disease may simulate this affection, and often only a careful study of the urine and the general symptoms will establish the diagnosis. The question becomes still more complicated if albuminuria is associated with brain tumor.

In glycosuria and leucocythæmia somewhat analogous appearances are found, and again an examination of the urine, as well as that of the blood, may be necessary before reaching a diagnosis.

The white spots are distinguished from plaques of choroidal atrophy by the absence of pigment-heaping. The snow-bank

appearances differ from retained marrow sheath (page 454), by the fact that the latter stretches away from the margin of the disc, usually ending in a fan-shaped border, and is unaccompanied by the changes in the macula, or by retinal œdema. Fine lesions of the choroid in the macular region may be mistaken for somewhat similar retinal changes; but they are more scattered, more yellow in color, usually unassociated with distinct loss of vision, and less liable to assume a stellate or radial appearance.

TREATMENT.—Local measures are practically of no avail. The case must be managed on the general principles suited to the form of kidney disease which is present. A proper remedy in most cases is iron, usually in the form of the tincture, and often advantageously combined with bichloride of mercury.

Diabetic Retinitis.—This occurs in several forms. It is always bilateral, but there are no pathognomonic signs.

Hirschberg describes two varieties of diabetic retinitis—an *exudative* and a *hemorrhagic* form. They are late manifestations of diabetes, and are seen at a time when gangrene, carbuncle, hemiplegia, and other serious complications of this disorder arise. In any case of diabetes of long duration retinitis is seldom absent, although it may sometimes be difficult to find the lesions, because they exist in the periphery of the eye-ground. This is especially true if the complication of high myopia, or cataractous lens, is present.

Much more commonly than in the retinitis of albuminuria, opacities and hemorrhages occur in the vitreous humor. The student should never neglect to make an examination for sugar in the urine in any case in which he finds hemorrhagic retinitis, or small hemorrhages associated with white spots of exudation, especially around the macula.

TREATMENT.—There is no local treatment. The discovery of such a condition may lead to the finding of sugar in the urine, but more commonly the patient is already conscious of his disease and is under medicinal and dietetic treatment.

Leucocythæmic Retinitis.—The retinal changes seen in splenic leucocythæmia, to which variety of the disease they are almost exclusively confined, affect both eyes, usually one more than its fellow.

The most important ophthalmoscopic appearances are slight swelling of the papilla, pallor of its surface, veiling of its edges, and some opacity of the retina, especially along the lines of the vessels. The latter present a striking appearance. The veins are broad, distended, and of a somewhat rose-red color; the arteries, in contrast, narrow and orange-yellow, which color substistutes the ordinary fiery red of the choroid, the vessels of which, if they are visible, present a yellowish-red tint.

Very prominent lesions are white spots with red borders, especially near the equator and in the region of the macula lutea. The spots vary in size and are often somewhat elevated in appearance. They are due to a collection of lymph corpuscles, and the red border to an extravasation of blood corpuscles.

On the other hand, retinitis associated with leucocythæmia may not present characteristic appearances, but consist simply of a diffuse opacity of the retina, or appear in the form of hemorrhagic retinitis. When the yellow spots which have been described develop in the macula, it is sometimes difficult to distinguish the case from one produced by albuminuria. Indeed, albumin in the urine may be present with leucocythæmia. In any doubtful case, a careful blood examination will reveal the true nature of the disease.

In addition to the types of retinitis thus far described, there are certain rare forms.

Proliferating Retinitis.—This is a development of connective tissue in the retina, and consists of dense masses of bluish-white or white color, which are developed from the retina and stretch out into the vitreous humor. They often cover a considerable portion of the fundus and hide the papilla, which may with difficulty be seen through the intervening spaces. Sometimes the masses follow in the course of the bloodvessels, which in part may lie beneath them and in part pass over them; those which lie above the masses are occasionally newly-formed bloodvessels. As complicating circumstances, there may be detachment of the retina, opacity, and hemorrhage into the vitreous.

The disease is said to be most common in young people, and has been ascribed to the results of an inflammation, but now and then develops from repeated hemorrhages.

A retinitis presenting similar appearances has been described in connection with oxaluria. Oxaluria may produce several types of retinal affection, and is certainly one of the causes of a very pronounced retinal irritation.

Central Punctate Retinitis (*Retinitis punctata albescens*).—This peculiar type of retinal affection, originally described by Mooren, occurs in middle-aged or old people, and is under the influence of no known dyscrasia.

A great number of striæ or spots, resembling in color the reflex of the sclera are visible. The retinal vessels are not covered by the spots, and the papilla shows but slight changes. The peripheral field of vision is unaffected; in the centre there may be a scotoma. Sometimes vitreous hemorrhages occur. Atheromatous changes in the vessels elsewhere in the body are found.

Treatment.—This consists in depletion from the temple, and iodide of potash or other alterative of similar physiological action.

Pigmentary Degeneration of the Retina (*Retinitis pigmentosa*). —Although this affection is usually entitled *retinitis pigmentosa*, the phenomena of inflammation are absent, and it consists of a degeneration of the nerve tissue, associated with great contraction of the bloodvessels and the accumulation and deposition of pigment of well-nigh characteristic form, in the substance of the retina.

Symptoms.—The ophthalmoscopic appearances of a typical case are as follows:—

(a) *Pigmentation.*—The pigment masses assume an appearance resembling bone corpuscles, and by the frequent union of their processes, simulate the Haversian canals. By preference, the pigmentary depositions are more marked on the temporal side. They begin far out in the periphery of the eye-ground, often lying along the course of the main vessels, and gradually approach the papilla, the macula region remaining for a long time unaffected. A zone midway between the centre and far periphery is the favorite seat of pigmentation.

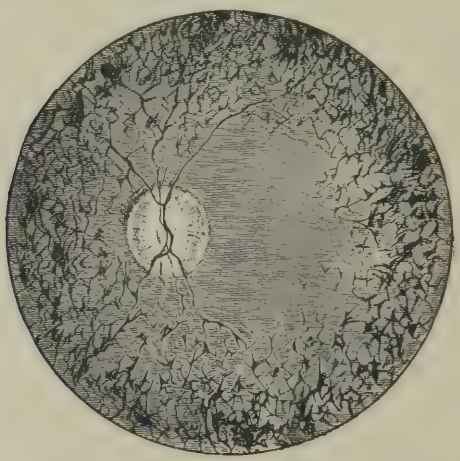
(b) "*Wainscotted Fundus.*"—A perfect picture of the appearance already described in connection with superficial choroiditis is visible on account of the absorption of the retinal pigment epi-

thelium and the exposure of the larger vessels of the choroid. The overlying retina is distinctly gray.

(c) *Contraction of the Vessels.*—This is present in both systems. The vessels may be as thin as threads. Often their walls exhibit patches of opacity, and they are accompanied by fine white lines. Not only are they greatly contracted, but they are apparently diminished in number.

(d) *The Changed Nerve-head.*—The color of the papilla, according to the stage of the disease, is of a yellowish-gray, yellowish-red, or waxy tint. It finally becomes dull white and atrophic.

Fig. 126.



Pigmentary degeneration of the retina (Jaeger).

With the exception of a slight veiling, its edges are plainly marked.

(e) *Opacities of the Media.*—Posterior polar cataract may be a complication. Opacities in the vitreous are very uncommon.

(f) *Nystagmus.*—Quite frequently a quick lateral oscillation of the eyeballs, or nystagmus, is present, especially in congenital cases.

The subjective symptoms are :—

(a) *Depreciation of Central Vision.*—Visual acuity may be but slightly affected in the earlier stages, although usually the perception of green and red is below the normal (Oliver). Indeed,

reasonably good central vision may remain, even when the disease is very widespread, but it finally sinks with the progress of the affection.

(b) *Contraction of the Field of Vision.*—This is concentrically contracted according to the amount of degeneration, and the contraction may be so excessive that only a very small area of the field remains. In rare instances, even with extreme narrowing of the visual field, there is still moderately good central vision, and the patient may read by fixing a single word at a time. Finally, the contraction goes on to complete blindness. The defect in the field may also be irregular, according to the position of the areas of degeneration, and it sometimes assumes the form of a broad, ring-scotoma.

(c) *Night Blindness.*—Often this is the first symptom which calls attention to the case. The patient is uncertain in his movements and stumbles over articles as soon as twilight begins, becoming quite helpless in the dark. Night blindness is not always present, and in rare instances diminished light is a relief to the patient. Such a condition is due to hyperæsthesia of the retina.

Atypical Types.—Instead of the usual deposition of the pigment, this may be massed in the macular region. Then the central vision is much affected, and a scotoma appears around the point of fixation. In other instances the pigment masses do not assume the characteristic shapes and grouping which have been described, but are scattered all over the fundus in irregular masses, and are associated with clear, shining spots lying beneath the retinal vessels. Finally, cases occur presenting the usual subjective symptoms, but without the accumulation of pigment—really forms of sclerosis of the retina without the formation of pigment—and a few instances, associated with a broad peripheral zone of choroidal atrophy, have been described.

Causes.—The disease is markedly hereditary. In numbers of instances, consanguinity of the parents of the patient has been found; indeed, the disease has been attributed to this alone. Hereditary syphilis has been given as a possible cause of retinitis pigmentosa, but this has not been proven. The affection is found among deaf-mutes, idiots, and epileptics, and in this sense is con-

nected with morbid states of the nervous system. Very often no cause can be assigned. The disease is either congenital or begins in childhood.

Its pathological anatomy has not been definitely settled. There is a sclerosis of the connective tissue of the retina and a wandering forward of the hexagonal pigment, but it is not quite certain whether the beginning of the disease is in the superficial layers of the choroid, or in the pigment epithelium. It is always bilateral.

Diagnosis.—A fully formed and typical case of retinitis pigmentosa presents no difficulties in diagnosis. It may be distinguished from disseminated choroiditis by the difference in the pigmentation of the two diseases.

Its differential diagnosis from certain types of retino-choroiditis seen in acquired syphilis is difficult, especially when the latter manifest themselves in the form of atrophy of the retina and a gathering of pigment spots, beneath which the exposed choroidal vessels are visible. In retino-choroiditis, however, the pigment spots do not have the characteristic form ; they are much scattered, and do not follow the bloodvessels ; besides vitreous opacities, which are very rare in pigmentary degeneration of the retina, are usually present.

A patient complaining of night blindness, or seen stumbling about during the twilight, should be subjected to a careful examination of the far periphery of the eye-ground, if necessary after dilatation of the pupil, because occasionally the pigment is confined to this region and might be overlooked by a careless observer.

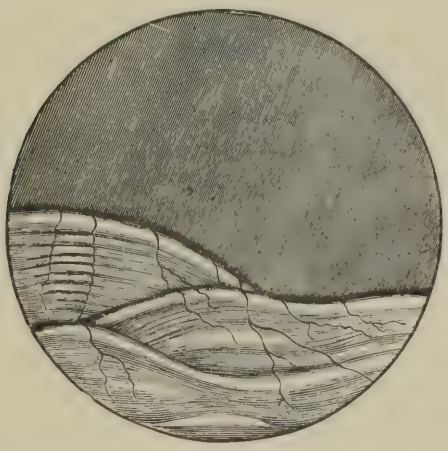
Course and Prognosis.—The course of pigmentary degeneration of the retina having begun in childhood, progresses steadily onward with ever-increasing contraction of the field of vision until finally, usually by middle life, sight has been obliterated, with, perhaps, the exception of a slight eccentric preservation of the field. The prognosis is hence unfavorable under all circumstances and in spite of all known endeavors to modify the course of the disease. Occasionally, when the pigment accumulation has advanced far over the retina, but the macula still is free, the disease remains stationary for long periods of time.

Treatment.—This is of little avail. Strychnia in full doses, especially by the hypodermic method, has been recommended. If there is any suspicion of syphilitic taint the usual remedies are applicable. Galvanism has been tried, and under its influence it is stated that the progressive contraction of the field of vision has been stayed, although no improvement in the acuity of central sight was obtained. It certainly should be given a trial in every case.

Detachment of the Retina (*Ablatio retinæ ; Amotio retinæ*).—Idiopathic separation of the retina from the underlying choroid, is due to an accumulation of a serous fluid, between these membranes.

Symptoms.—The student will observe, as he examines the various portions of the fundus, with the ophthalmoscope (direct method), an alteration of refraction at the area of separation ; the surface of the elevation thus produced being out of focus as compared with the rest of the eye-ground. Thus, if the general

Fig. 127.



Detachment of the retina (Wecker and Masselon).

fundus is hypermetropic, the detached portion will be more hypermetropic, and require a stronger convex glass for the study of its surface ; if it is highly myopic, a weaker concave glass, or, it may be, a low convex lens.

The normal red color of the fundus is lost as the detached retina is approached, which appears a gray or bluish-gray membrane stretching forward into the vitreous, containing folds which give rise to a sheen. The intervening furrows present a greenish-gray reflex, and the whole oscillates with the movements of the eye. This is true when the underlying substance is fluid; if it is a solid, neither folds nor tremulousness in the membrane are present.

The retinal vessels rise over the separated portion, first lose the light streak, and finally appear as dark tortuous cords (Fig. 127). They apparently are of smaller size than normal, and when followed backward they pass out of focus at the edge of the detachment, which is usually sharply marked from the normal fundus; indeed, there may be a yellowish border and occasionally accumulated pigment. The amount of discoloration of the detached area depends upon whether the case is recent or not, and upon the character of the underlying substance. In the earlier stages the transparency is not lost and the gray color, previously described, may not be present.

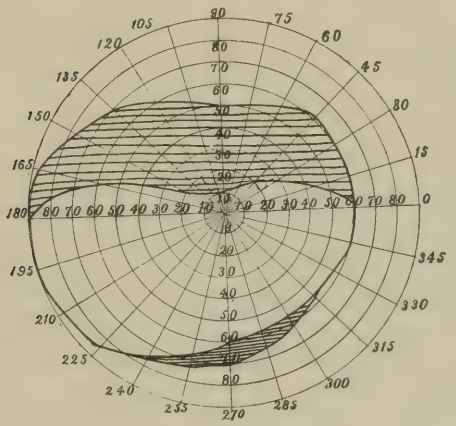
The detachment, either *partial* or *complete*, may occupy any portion of the fundus, but most commonly is found below, even when it has begun in the upper part. Sometimes the detachments are quite small, like a series of furrows, and at other times an almost circular circumscribed separation occurs. Finally, the subjective signs of detachment may be present without discoverable elevation of the retina, but over the area (which subsequently separates) there is complete loss of the light reflex from the retinal vessels (Loring).

Unless the macular region is directly involved, vision is not obliterated, but there is always interference with sight. This may develop suddenly. The field of vision is lost in an area corresponding to the detached retina, and the completely darkened portion is usually bordered by a zone of imperfect vision corresponding to an area of retina not yet separated, but elevated above its normal plane. If the retina is detached below, the upper portion of the visual field is obliterated; if above, the lower portion, and so on. (Fig. 128.)

The patients complain of distortion of objects (metamor-

phopsia); of floating spots before the eyes, due to the frequent presence of vitreous opacities; of an appearance like a cloud, due to the scotoma produced by the separated area; and of phosphenes, although the latter cannot be elicited by pressure on the eyeball over the separated area.

Fig. 128.



Field of vision in detachment of the retina below. There is slight contraction of the preserved field.

Causes.—The causes of retinal separation are: High (malignant) myopia; traumatisms; effusion of blood, preceded usually by hemorrhages into the vitreous or retina; intraocular tumors (sarcoma of the choroid) or subretinal parasites (cysticercus); tumors and abscesses in the orbit; and diseased conditions of the eye like retinitis, cyclitis, irido-cyclitis, etc. In the last instance, the detachment is found after removal of the shrunken globe.

Mechanism.—Leber and Nordenson, hold that the cause of idiopathic retinal detachment is a pathological change in the vitreous, which shrinks and thus occasions traction. The latter observer believes that the primary cause is disease of the choroid and ciliary body. Nordenson's researches further show that more men than women are affected, that myopic refraction most frequently is present, and that the separation is more apt to occur in an eye in which the visual disturbance has rapidly developed. The condition may become apparent suddenly or arise slowly.

Often the patient will state that the defect was first noted after rising quickly from a stooping posture.

Diagnosis.—No difficulty arises in detecting a large detachment of the retina by attending to the symptoms already detailed. An extensive or complete detachment which floats far forward may be examined by oblique illumination. When the vitreous is full of opacities, a study of the field of vision is useful. When the substance underlying the detached portion is *fluid*, there are usually diminished tension of the eye-ball, and the appearance of furrows in the separated tissue, which trembles with the movements of the eye, symptoms which are absent when a *solid growth* has caused the separation. Important diagnostic points are the loss of the light reflex of the vessels, and their dark color over the area of separation. From this point they can be followed, and can be seen to regain the light reflex in passing over the normal retina.

Prognosis.—This is very unfavorable, and many of the suggested means of treatment have proved unsatisfactory. In rare instances, there is spontaneous re-attachment of the separated retina.

Treatment.—This should include rest in the prone position and the use of a pressure bandage, associated with pilocarpine-sweats. Alteratives, like the iodides, have been tried, and improvement after instillations of eserine has been reported. The author has tried eserine in a few instances and had one good result.

Various forms of operative procedure have been attempted: sclerotomy and iridectomy, the latter certainly should be condemned; evacuation of the subretinal fluid by puncture and aspiration; and drainage by means of a gold wire. Recently Schoeler has reported successes by the injection of iodine and the production of sufficient inflammation to reunite the choroid with the separated retina. Others have not found this method free from danger. In cases of detachment due to tumor, the question of enucleation is to be considered.

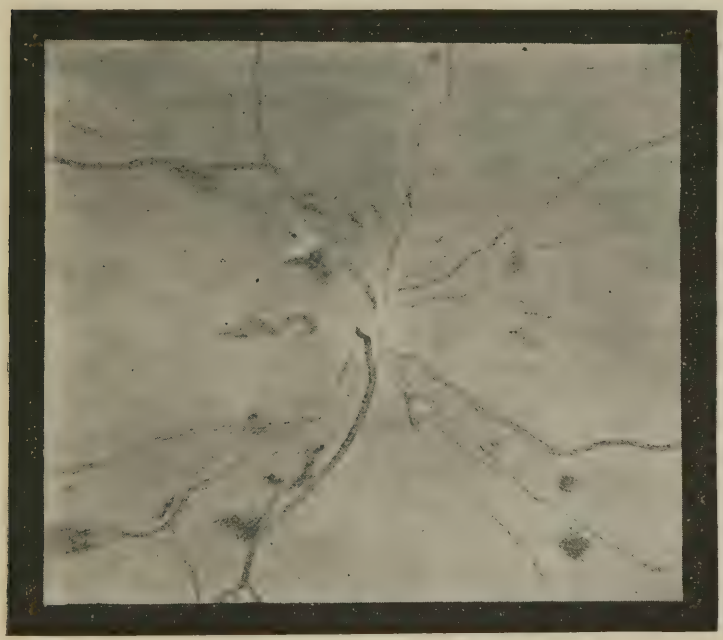
Certainly in spontaneous or traumatic detachment, the subretinal contents being fluid, if a compressing bandage, instillations of eserine and pilocarpine-sweats should prove unavailing,

scleral puncture and evacuation of the fluid, followed by a careful rest treatment, would seem a rational procedure.

The following phenomena are especially concerned with pathological changes in the blood itself, the peri-vascular tissues and the vessel walls, and are indicative both of local disease or, as in many of the inflammatory stages, of disease in distant organs:—

Hemorrhages in the Retina (*Apoplexy of the Retina*).—The appearances of retinal hemorrhage have been described in the general symptom-grouping, and as they occur with so-called hemorrhagic retinitis.

Fig. 129.



Retinal hemorrhages (Gowers). The patient suffered from pernicious anæmia.

Hemorrhages (unassociated with inflammation) may be in any of the layers of the retina, or, bursting through the limiting membrane, they may occupy the vitreous humor. By preference they are found along the course of the larger vessels; a favorite

site is the macula. Hemorrhages originating in the outer sheath of the optic nerve may appear at its margin and spread into the surrounding retina.

There are no external appearances to indicate that bleeding into the retina has occurred.

Causes.—Some of these have been enumerated in connection with hemorrhagic retinitis, and hemorrhage into the vitreous. The following *résumé*, based upon the classification of Dimmer, may be added :—

(*a*) Hemorrhages caused by changes in the composition of the blood and the tissues of the bloodvessel walls : Pyæmia, septicæmia, ulcerating endocarditis ; diseases of the liver, spleen, kidney, and atheroma of the vessels ; loss of blood (menorrhagia, hæmatemesis) ; anæmia (simple and pernicious), hæmophilia, purpura, and scurvy ; diabetes and gout ; malaria and recurrent fever.

(*b*) Hemorrhages caused by disturbances in the circulation : Hypertrophy of the heart and stenosis of the valves ; thrombosis of the central vein of the retina, and embolism of the central artery ; suffocation, compression of the carotid, and hemorrhages in the newly-born ; and the menstrual disturbances.

(*c*) Hemorrhages caused by sudden reduction of the intraocular tension ; *e. g.*, after iridectomy in glaucoma, and by traumatisms. Among the latter may be classed retinal hemorrhages after large cutaneous burns.

Prognosis.—This depends upon the extent and situation of the hemorrhages.

Hemorrhages form a prognostic guide of the disease which has caused them, and, in elderly people, may be a warning of future hemorrhages into the brain. Hemorrhagic glaucoma, detachment of the retina, and the formation of dense opacities in the vitreous humor may be complications.

Treatment.—All use of the eyes must be forbidden. Locally, a weak solution of sulphate of eserine may be employed, especially in elderly people. Internally, the medication must be governed by the probable cause. Frequently, cardiac sedatives, ergot, small doses of pilocarpine, and later, alteratives, like iodide of potash and bichloride of mercury, will be required.

Changes in the Retinal Vessels and their Walls.—Independently of the various grades of dilatation and contraction of the

vessels, to which reference has been made, certain other changes, due to *vasculitis* and *peri-vasculitis*, are seen.

The so-called *peri-vasculitis* is characterized by the appearance of white stripes along the vessels, or, rather, the vessel walls become apparent by their conversion into whitish tissue, due probably to an infiltration of the adventitia with lymph corpuscles. This may be so extensive that the entire set of vessels is converted into a series of branching white lines.

Fig. 130.



Peri-vascular disease in the retinal vessels (Gowers). The arteries which pass upward are concealed by white bands.

Peri-vasculitis, thinning and atrophy of the vessels, together with thickening of their walls, are due to various inflammatory diseases of the retina and optic nerve.[1]

[1] Alternate contractions and widening of the calibre of the vessels, together with undue tortuosity and grayish reflections from their walls, have been described in connection with general arterial sclerosis. Conversion of one or

Aneurisms.—Aneurism of the central retinal artery is an extreme rarity. It has been seen as a spindle-shaped sac, pulsating synchronously with the heart. Miliary aneurisms, usually spindle-shaped, have been noted in the small arterial twigs, and may be looked upon as significant of a similar condition of the vessels in other organs, especially the brain. The student should not mistake varicosities in the veins for aneurisms. Arterio-venous aneurism of the retina has been described as the result of injury (Fuchs).

Embolism of the Central Artery of the Retina.—An embolus may lodge in the central artery of the retina, or in one of its branches.

Symptoms.—The main branches of the *artery* are thin, and can be followed only a short distance over the edge of the papilla into the retina, and there is a diminution in the number of ramifications. The *veins* are also contracted, and very often they present unequal distension. They may present ampulliform broadening, alternate contractions and swellings, and especially a contraction at the disc, succeeded by broadening in the periphery, where they assume almost their natural breadth. There is no change of diagnostic significance in the color of the blood. Pressure from before backward, so as to increase the intraocular tension, causes a regular current to flow through the vessels. This consists of broken cylinders of blood, separated by clear spaces, which move sluggishly along. In the veins, without such pressure, and, it may be, directly after the accident, an *intermittent blood stream* is often visible. The appearance is not unlike that produced when air is allowed to mix with a fluid in a tube. Occasionally a few hemorrhages are seen along the course of the vessels.

The *papilla* assumes a pallid, grayish-white appearance, owing to the lack of blood in its capillaries. An *opacity in the retina*

more vessels into white cords, among the larger ones of which a thin blood stream may be seen, while the smaller ones are collapsed, has been attributed to *endarteritis obliterans*. Glistening white patches on the principal arteries, associated with opacity of the papilla and disease of the vitreous, are sometimes observed, and, on the grounds of a few anatomical researches, have been ascribed to the formation of granular deposits of lime.

develops in the form of a grayish-white, *fog-like œdema*, sometimes permitting the reddish tint of the normal eye-ground to shine through it, and sometimes being so opaque that it is quite milk-like in its density. This occurs especially in the neighborhood of the papilla and in the macular region, the space between the two often being free, although gradually the areas meet. The opacity comes on within a few hours after the accident, or may be delayed for a day or two. The author has watched it form within twenty minutes after the lodgment of an embolus.

Characteristic of sudden obstruction of the arterial circulation, is the formation in the macula lutea (corresponding to the position of the fovea) of a central red spot, which resembles a round hemorrhage in the midst of the milky-white œdematous area. It is known as the *cherry-red spot* of the macula lutea, and is caused by the red color of the choroid appearing through the much thinned retina. As a rare complication, at least in the dark-skinned races, the usual cherry-red spot has been replaced by a coal-black one. The spot appears at the same time with the opacity in the macula lutea. It is less likely to form where there is a stoppage of a branch of the retinal artery instead of one of the main trunks.

In the course of several weeks there is a gradual subsidence of the retinal œdema, the optic disc undergoes atrophy, and the retinal vessels are shrunken or even converted into white cords; if there have been hemorrhages, spots of degeneration appear at their positions, and not infrequently cholesterin crystals and pigment markings may be seen around the disc and in the macula lutea.

Instead of the *main trunk*, a *branch* may receive the embolus, which, in some instances, actually becomes visible to the ophthalmoscope as a yellowish body, but, more frequently, is assumed to be present because at one point in the artery there is a swelling, while beyond it there is complete obliteration of the vessel, or its reduction to an extremely thin calibre. The secondary retinal changes are then confined to the area supplied by this vessel.

Vision is lost with characteristic suddenness. Occasionally, preceding the blindness, there is some uncertainty in vision, or

a little headache and giddiness, with flashes of light, representing a species of aura. In obstruction of a branch by an embolus, on the other hand, there may be very good acuity of vision. Indeed, in some instances, even in embolism of the upper branch of the central artery, this has been normal. The presence of a *cilio-retinal vessel* may be the means of preserving good acuity of vision.

The *field of vision* varies according to the extent of the blocking of the circulation. In cases where the obstruction is complete, even light perception is absent. If only a branch has been occluded, that portion of the retina which receives its blood supply from this source will be paralyzed, and the opposite area of the field will be darkened. The presence of a cilio-retinal vessel permits, as a rule, an oval portion of the field of vision to remain in the neighborhood of the fixation point. Even if the main stem of the artery is obstructed, a portion of the nasal retina may retain its functional activity. An uncommon effect is a central scotoma.

The intraocular tension is sometimes raised, sometimes lowered, and sometimes unaffected. The pupil may be large and irresponsive to light, if the case is one of complete stoppage of the central artery.[1]

Causes.—The most frequent cause of embolism of the central artery of the retina is valvular disease of the heart, especially if complicated by a fresh endocarditis. It also occurs with general arterial sclerosis, aneurism of the aorta or of the carotid, and with Bright's disease and pregnancy; in a few instances, it has been noted with chorea. It may occur at almost any age of life and has been recorded from the fifteenth to the eightieth year. The accident usually is unilateral, simultaneous embolic plugging of the central artery of each eye being very rare.[2]

Diagnosis.—The ophthalmoscopic picture just detailed indicates that there has been an interruption in the retinal circulation,

[1] The symptoms which have been described refer to typical cases; a variety of exceptions occur.

[2] In a certain number of cases, although all of the ordinary ophthalmoscopic appearances of embolism of the central artery of the retina have been present, it has been impossible to assign a cause.

but does not prove that the stoppage has been due to embolism. Similar appearances occur with thrombosis, and with hemorrhage into the sheath of the optic nerve. Thrombosis of the central vein, moreover, may be so situated as to press upon and occlude the lumen of the artery lying beside it. This still further complicates the diagnosis. Certain points of difference will presently be mentioned.

Prognosis.—This is exceedingly unfavorable, and in most instances blindness is the result. Even when temporary improvement occurs, subsequent atrophy of the nerve is likely to ensue. In embolism of a branch, the prognosis is more favorable, and, as has been stated, normal central vision may be present. The presence of a cilio-retinal vessel improves the prognosis.

Treatment.—This does not often prove of avail. In the hope of restoring the circulation by reducing the intra-ocular tension, sclerotomy, iridectomy, and repeated paracentesis of the anterior chamber have been practised, but without success. Vigorous kneading or massage of the eyeball has been recommended, and in some cases has been followed by good results. It should be given a faithful trial. With the massage, inhalations of nitrate of amyl may be given (Gifford).

Thrombosis of the Retinal Artery.—This may occur in heart disease, disease of the bloodvessels, and alteration of the composition of the blood. The ophthalmoscopic picture does not differ from that described under embolism. The symptoms upon which a differential diagnosis may be attempted are stated by Priestley Smith to be: Previous attacks of temporary blindness in the affected eye, a simultaneous attack of temporary blindness in the unaffected eye, and giddiness, faintness, and headaches—symptoms which are absent in embolism.

Treatment.—This is the same as that recommended for embolism.

Thrombosis of the Central Vein.—This has been observed a number of times as the result of a phlebitis, and, also, with heart disease when embolism might have been suspected.

In some instances, the appearances have been closely similar to those of embolism; in others, they have assumed an inflamma-

tory character similar to that described under hemorrhagic retinitis, of which it may be a cause. Several grades of this condition have been recorded. If, in addition to the ordinary disturbances present in embolism, the ophthalmoscope reveals tortuosity of the vessels, engorgement of veins, and normal or contracted calibre of the arteries, venous pulse, and interrupted venous circulation and retinal hemorrhages, thrombosis of the central vein may be suspected (Angelucci).

Traumatisms of the Retina.—Under this general term may be included traumatic anæsthesia, traumatic amblyopia, detachment, and rupture. There are no characteristic symptoms common to all varieties, but pain, and disturbance of vision, in part due to the direct injury, and in part to a transient astigmatism, are likely to be present.

(1) *Traumatic Anæsthesia* is the name proposed by Leber for those cases occurring after a blow upon the eye without discoverable ophthalmoscopic changes, but with considerable defect in vision and contraction of the visual field—defects, moreover, which may remain unchanged for a long time, or, indeed, never entirely pass away.

The *treatment* is rest and the use of strychnia internally, or by hypodermic medication.

(2) *Traumatic Amblyopia* (*Commotio Retinæ*, *Œdema of the Retina*) is a condition also arising from an injury, especially a blow from a ball, cork, or similar body, and is attended by the following symptoms: Hyperæmia of the globe marking the position of contact of the missile; clear media; and gray opalescence of the retina, especially in the macular region, but also around the papilla, which may be somewhat hyperæmic. If the retina under the point of contact is visible, this also may exhibit the white infiltration. In addition, several pale yellowish spots, and, occasionally, small hemorrhages may be present. The vessels are unchanged, or, in some instances, are contracted (arteries), or distended (veins), and pass *over* the gray area. A central scotoma may exist.

An interesting complication is the development of a transitory astigmatism, which helps to reduce the visual acuity.

The gray infiltration forms quickly and is also absorbed with

rapidity, usually having subsided at the end of two or three days, although the visual defect may last for longer periods. Decided retino-choroiditis, the result of concussion, may occur, and this fact should be remembered in investigating old cases of choroidal disease presenting themselves with meagre history.

The *treatment* consists in keeping the pupil dilated with atropine and covering the injured eye with a shade or dark glass, all use of the uninjured organ being forbidden.

(3) *Detachment of the Retina*, as the result of injury, has been mentioned.

(4) *Rupture of the Retina*.—Rupture, uncomplicated by choroidal fissure, the result of injury, is a rare accident, and might be recognized by observing the frayed edges of the tear and seeing the exposed choroidal tissue. Loring describes such an occurrence following a fall upon the back of the head.

Retinal Changes from the Effect of Sunlight (*Solar Retinitis*). —It has been experimentally proven that retinal changes can be produced in animals' eyes by concentrating upon them the rays of the sun. Clinically, analogous disturbances have been found in the human retina after exposure to intense light, most frequently in those who, with unprotected eyes, have watched an eclipse of the sun.

The *symptoms* are: A dark spot in the field of vision (positive scotoma), distortion of objects, and evidences of slight retinitis or retino-choroiditis in the macular region. Thus, there may be a maroon-colored area with a central gray patch, and numerous faintly-marked yellowish-white dots.

The *prognosis* depends upon the length of exposure. Frequently the visual disability is permanent.

Glioma of the Retina.—Gliomata are tumors having as their prototypes neuroglia-cells, and ordinarily are found in the brain and spinal cord. A tumor composed of cellular elements occurs in the retina resembling the cells of its granule layer, and, according to some pathologists, should be classed as a sarcoma, although its clinical characteristics are very different from those presented by the usual forms of the latter growth.

According to the layer of the retina from which the growth takes its origin, it has been described by systematic writers as

glioma endophytum and *glioma exophytum*. In the former, the vitreous chamber is occupied by the growth; in the latter, it lies between the retina and choroid.

The tumor is usually of a light-gray or grayish-red color. It is subject to various degenerative changes—fatty, cheesy, and calcareous—and tends, on the one hand, to invade the orbit, involve the optic nerve, and travel by the way of its sheath to the brain, and, on the other, to pass forward, bursting through the sclerotic and cornea. Recurrence *in loco* after extirpation may occur, and metastases, although not common, do take place.

Like sarcoma of the choroid, it passes through several stages. In the first, there are no signs of irritation, the media are clear, the pupil is dilated, and often the growth produces a whitish reflection which has given rise to the designation *amaurotic cat's eye*. As the disease progresses, symptoms of irritation and increase in the size and tension of the globe become manifest, and the process begins to involve the optic nerve. Finally, the tumor bursts from its bounds, perforates the globe at its corneo-scleral junction, grows rapidly, involving the orbit and neighboring temporal regions, and presents a huge vascular mass, to which, in former times, the name *fungus hæmatodes* was applied.

Glioma of the retina is either congenital or occurs in infancy. It has also been described in older children. It is not a common affection. Hereditary disposition has not been established. Several members of the same family may be affected. One or both eyes are likely to be involved.

Diagnosis.—This tumor must be distinguished from purulent deposits in the vitreous, the result of purulent choroiditis, and to which the name *pseudo-glioma* has been applied. The distinguishing features are detailed on page 405. If glioma is complicated by iritis and cyclitis, which occasionally happens, the differential diagnosis is more difficult. In any case of doubt the eye should be enucleated.

Sarcoma of the choroid is differentiated from glioma by the fact that the former usually occurs at a later period of life, and that in the earlier stages of each affection the ophthalmoscopic findings are different. In glioma the tumor is seen to *involve* the retinal

structure which does not, as in sarcoma, merely act as a covering to the growth.

Prognosis.— This is unfavorable, and if the disease has involved the optic nerve or bursts from its bounds, it is fatal. Still, numbers of recoveries are on record, and an opinion must be based on the extent of the disease, the condition of the optic nerve being the most important element in the prognosis. In a number of fatal cases which have been analyzed (Lawford, Collins) the optic nerve was unaffected only in four. Under unfavorable circumstances recurrence in the orbit occurs, with extension to the brain, and, more rarely, metastasis to a distant organ.

Treatment.—Thorough enucleation, with division of the optic nerve as far back as possible, is the only treatment. Any suspicious tissue in the orbit is to be sacrificed. In several instances both eyes have been removed, and recovery after such procedure has been recorded.

Subretinal Cysticercus.—This, like the presence of the same parasite in the vitreous, is exceedingly uncommon in this country.

CHAPTER XVI.

DISEASES OF THE OPTIC NERVE.

Congenital Anomalies.—*Opaque Nerve Fibres.*—In the normal eye the fibres of the optic nerve cease to be invested with a medullary sheath at the lamina cribrosa, and consequently the axis cylinders, which are distributed to the retina, are transparent. As an anomalous condition, sometimes bilateral, but more frequently only in one eye, the medullary sheaths reappear at the upper or lower margin of the disc as a dull or glistening bluish-white patch, which extends to a variable distance out into the retina, and ends in a somewhat feathery or fan-shaped margin. Usually the retinal vessels are hidden by the patch, but reappear again on its distal side.

This plaque may be a single one above or below, or it may appear both above and below the disc, more rarely on the nasal side, and very exceptionally, if ever, upon the temporal margin. The size varies from a small expansion to a huge sweep of white tissue, continuous above and below with margins of disc, and taking somewhat the general direction of the vessels, which are wholly or in part concealed.

This condition produces no change in vision, except an increase in the size of the normal blind spot, and should not be mistaken by the beginner for pathological lesions, like an atrophy of the retina and choroid, or a bank of fatty degeneration as it occurs in retinitis albuminurica.

Coloboma of the Sheath of the Optic Nerve.—This congenital anomaly is characterized by an apparent augmentation of the surface of the disc, and an excavation of the papilla backward and downward. The periphery is usually bounded by pigment massing. There is an unequal division of the retinal vessels, which are first seen as they bend over the margin of the exca-

vation. It is a rare anomaly, and has been mistaken for posterior staphyloma. It depends upon imperfect closure of the fœtal fissure.

Irregularities in the Disc.—Instead of its usual round or oval shape, the disc may be markedly irregular in outline, one side being occasionally at an apparently lower level than the other, or it may present a gibbous appearance.

When the nerve-head fails to fit the choroidal aperture accurately, a space is sometimes formed, usually crescentic, known as a "cone" or "conus" (Loring). This generally is seen at the outer side of the papilla, but also inward, below, and very rarely above. It should not be confused with the cases of atrophy of the choroid seen in myopic eyes, to which the name *posterior staphyloma* is given (page 353), nor with the crescents of choroiditis seen in astigmatic and stretching eyes, in which the scleral ring broadens out into a semi-atrophic area of disturbed choroid, usually bounded by an irregular pigment line, and most commonly developed at the temporal side of the disc.

Shreds of Tissue on the Disc.—These appear as glistening white patches of tissue, sometimes almost transparent, at other times thicker and more opaque, either completely or partially hiding the vessels (De Beck). Occasionally, there is a white membrane, more or less completely covering the disc.

It seems most probable that these represent remains of the hyaloid artery, or appearances of its adventitious coat.

Hyperæmia of the Nerve-head (*Congestion of the Disc*).—The color of the intraocular end of the optic nerve varies considerably, and it is not accurate to describe a nerve-head as congested when it simply is redder than usual.

As Gowers points out, the term *simple congestion* is applicable when the papilla presents a dull red or brick-dust hue, which shades almost imperceptibly, through a blurred margin, into the general red color of the fundus; when it is more marked in one eye than in the other, the latter serving as a picture for comparison; when at some antecedent examination the same optic disc has presented a more natural color; and when its borders are obscured, but not hidden.

Under other circumstances—and the appearance is a frequent one—the surface of the nerve is covered by an overlying semi-transparent or œdematous layer, appears unduly injected, and its margins, especially the nasal ones, are veiled by retinal striations of mixed, fine grayish lines, and minute capillaries ordinarily not visible. The peri-vascular lymph sheaths at the same time are unduly prominent in the form of white lines along the central vessels, especially the veins.[1]

Causes.—(*a*) Refractive error, especially hypermetropia and hypermetropic astigmatism. In this connection, however, the caution of Loring should not be forgotten that the retinal striation and increased vascularity may be due to the presence of unusual amounts of connective tissue and the additional vascularity common to hypermetropic eyes.

(*b*) Prolonged exposure to glare and heat.

(*c*) Certain toxic agents presently to be described, and inflammation of the iris, usually of the syphilitic type.

(*d*) Certain disorders of the brain, especially various types of chronic insanity. It is extremely difficult, however, to decide whether congestion is caused by a cerebral condition, because under ordinary circumstances increased vascularity of the papilla is not an index of hyperæmia of the cerebral vessels.

Treatment.—This depends entirely upon the cause. Refractive error should be corrected, if this is the apparent origin of the trouble. Constitutional measures will be required if there is reason to believe that some general cause is at work. Mild cholagogues or saline waters are excellent adjuvants under any circumstances.

Anæmia of the Nerve-head.—This is not a disease peculiar to the optic nerve, but like retinal anæmia, occurs as part of a general anæmia, or because of obstruction to the central vessels, for example in embolism.

It is most difficult to interpret the significance of pallor of the papilla. Usually it will require more than mere inspection to decide whether or not a pallid disc is pathological.

[1] This appearance has received the name "hypermetropic disc."

I. Intraocular Optic Neuritis (*Papillitis, Neuritis, Choked Disc*).—Under the general term *papillitis* are included the various types of inflammation, either with or without the appearances of mechanical congestion, seen at the intraocular end of the optic nerve.

Symptoms.—Certain symptoms are common to all types of optic neuritis :—

(1) *Changes in the Nerve-Head.*—(*a*) Increased redness of the disc and obscuration of its borders.

(*b*) Swelling of the disc, loss of the light spot, complete hiding of the margins, the centre usually remaining redder than the periphery, which has a grayish tint and shades gradually in a descending slope into the surrounding retina. The swelling increases, assumes a mound-shape of mixed grayish color, and finally the form of the disc is lost, and its position can be inferred only by the convergence of the vessels. This swelling is measurable by the table given on page 119, and by the parallactic test. White spots and patches are often seen in the elevation, sometimes covering the retinal vessels. (Fig. 131.)

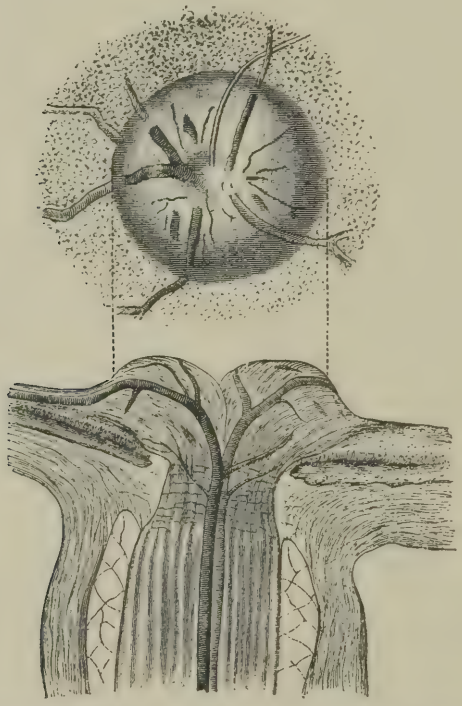
(2) *Changes in the Vessels.*—The *arteries*, smaller than normal, pursue a moderately straight course and are difficult of recognition, being always partly concealed by the swelling. Occasionally, spontaneous pulsation is visible. The *veins* are dark in color, distended and tortuous, and pass along the slope of the elevation, often dipping into the infiltrated tissue. The light streak is not lost, at least not where the vessel is clearly visible.

The tortuosity of the vessels is sometimes remarkable, and has been compared to the writhing snakes in the *Medusa-head*. The point of emergence and convergence of the vessels may be hidden by the infiltration, so that the centre of a papillitis seems somewhat destitute of vessels. In some instances thickening of the adventitia of the vessels gives rise to the appearance of white lines along their sides.

(3) *Hemorrhages.*—In many cases hemorrhages are found upon the swollen papilla, or in its immediate neighborhood. They are in the form of narrow, flame-shaped extravasations, if they lie in the fibre-layer, but may also assume other shapes,

if situated in a deeper plane. The number varies from a single hemorrhage to so many that the swollen nerve-head assumes a hemorrhagic form, or the surrounding retina may be freely occupied by elongated or other-shaped patches of blood.

Fig. 131.



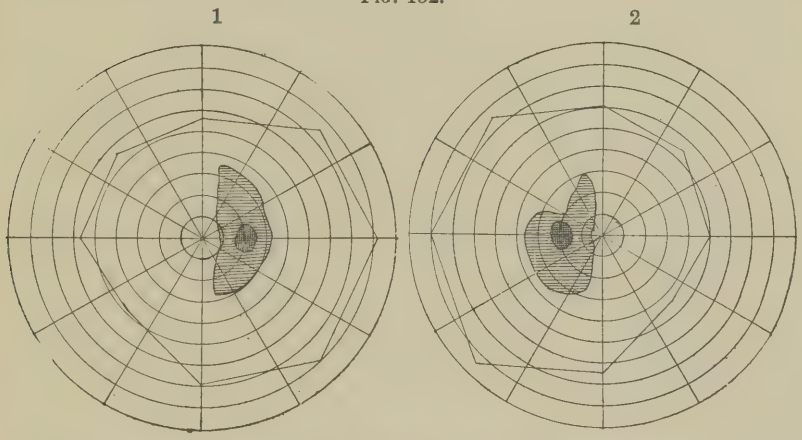
Schematic representation of the ophthalmoscopic picture of papillitis, and a longitudinal section of the nerve-head (Schmidt-Rimpler).

In addition to the ophthalmoscopic changes just detailed, the following points deserve notice:—

(1) *The Vision* in papillitis may be entirely unaffected. This is an important fact, and the mere presence of good central sight should never be considered cause to omit ophthalmoscopic examination. Usually one eye is more affected than its fellow. Impairment of sight may come on rapidly or slowly. Occasionally vision is lost with great suddenness, but this is rare.

(2) *The Field of Vision.*—The field of vision presents for consideration its periphery, which may at first be unaffected and later show irregular and concentric contraction; the increase in the size of the normal blind spot, which becomes correspondingly great in comparison with the amount of swelling; the formation of an abnormal blind spot or scotoma due to involve-

Fig. 132.



Abnormal size of the blind spot in papillitis. The central darker area represents the normal blind spot (reduced about .10) placed there for comparison.

ment of the axial fibres; the absence of half of the visual field (hemianopsia) when the intracranial mischief which may have been the cause of the papillitis is so situated as to produce this phenomenon; and finally, defective color-perception, which may exist when there is no change in central vision and no limitation of the form-field. As in other pathological conditions, the perception of red and green is usually lost before that of other colors.

(3) *External Appearances.*—There are no changes in the exterior of the eye indicative of swelling or inflammation in the nerve-head. There are no characteristic *pupillary* phenomena. If blindness is complete the iris is immobile.

(4) *Symptoms of Irritation* are practically absent.

Forms of Intraocular Neuritis.—Papillitis presents itself in different forms, and on this account, in former days, two

chief types were described, *choked disc* and *descending neuritis*, to which a third, or rather a different form of the second type, namely, *neuro-retinitis*, may be added.

When the symptoms were confined to the intraocular end of the optic nerve, and consisted of enormous swelling, giving the impression of mechanical compression, great distension of the retinal veins, and hemorrhages, the name *choked disc* was applied, and is constantly employed at the present day to describe that form of papillitis which is seen with brain tumor.

When the symptoms consisted of a moderate swelling and no unusual filling of the veins, but, on the other hand, of an exudation which produced discoloration and opacity of the papilla, and which was not sharply limited to it, but passed into the surrounding retina—the term *descending neuritis* was applied.

If an extensive participation of the retina was found, with hemorrhages along the vessels, spots of degeneration in the eye-ground, sometimes collected in a star-shaped figure and analogous to the appearances described under renal retinitis, the condition received the name of *neuro-retinitis.*

To avoid confusion of names, as well as to escape unproven theories in pathology, Leber proposed the general term *papillitis.*

In rare instances, papillitis is confined to a single eye.

Diagnosis.—The diagnosis of papillitis depends upon a direct ophthalmoscopic examination of the inflamed disc. The method of determining the height of the elevation has been explained.

The student should not mistake the slightly prominent discs that are occasionally seen in hypermetropia for papillitis. There may be a superficial neuritis in hypermetropia, and under these circumstances it is difficult at times to decide whether the disc has become inflamed under the influence of an intracranial disease or general trouble, or whether it is congested as the result of eye-strain. For this reason, one of the symptoms of intraocular neuritis, namely, redness of the disc, is not a sufficient one upon which to base a diagnosis.

Course, Complications, and Prognosis.—There are several grades of papillitis. The first stage usually is not, as might be expected, a simple congestion of the end of the optic nerve,

although preceding an actual intraocular neuritis there may be very marked tortuosity of the retinal veins, even before any obscuration of the disc itself is observed.

Gowers has divided papillitis into the *first stage*, or the stage of *congestion with œdema*, and the *second stage*, or that of *true neuritis*, or *papillitis*.

The most important symptoms of the first stage are indicated by the name which it has received. It presents different appearances, as Gowers has further pointed out, to the direct and indirect examination; in the former, the blurring of the edges of the disc is complete; in the latter it is not complete, and the margins may be seen through the cloudiness.

In the stage of true papillitis, the symptoms before mentioned in reviewing the general symptom-group occur.

The course of the disease is a very variable one. Occasionally swelling of the intraocular end of the nerve will come on with great rapidity; in other instances, it is slow in its course and lasts for months and even years, with progressive failure of vision.

When the evidences of inflammation and œdema begin to subside, the veins grow less distended, no new hemorrhages appear, or at least rarely, vessels previously obscured by the swelling begin to reappear, especially in the centre of the projection, which becomes depressed. Measurements with the ophthalmoscope show that the swelling is gradually sinking. The mixed grayish-red tint becomes more uniformly gray, and grows paler and paler, the borders of the disc begin to be visible, usually first upon the temporal side, until finally all margins again are apparent, at first a little mellowed, while the centre is still covered by the former inflammatory tissue.

Finally, the edges of the disc are clear, its color is white and atrophic, and its centre becomes apparent. Both sets of vessels are contracted, and often contain along their sides whitish tissue. Areas of retino-choroiditis and elevated patches of degeneration, marking spots of former hemorrhages, are often apparent.

Before a prognosis can be given, the cause must be definitely ascertained. If this, as for instance in the neuritis which occurs as the result of removable syphilitic deposits, is amenable to treatment, excellent results may be obtained.

Causes.—The most common cause of papillitis is *tumor of the brain*. The development of papillitis does not depend upon the size of the growth nor upon its situation, except that the morbid growths of the medulla are said not to originate optic neuritis. Tumors of the convexity of the brain are less liable to produce intraocular neuritis (Edmunds and Lawford), and those of the cerebellum are more liable to cause papillitis, especially of an intense type, having the characteristics to which the older writers applied the term choked disc. All types of morbid growth may originate papillitis—fibroma, sarcoma, glioma, carcinoma, solitary tubercle, and gummata. It also appears with echinococcus cysts, hæmatoma of the dura mater, and abscess of the brain.

Next in frequency to the various forms of brain tumor as a cause of papillitis is *meningitis*, especially when this is localized at the base of the brain, and is of tubercular origin. The appearances of the disc often assume those which have been called descending neuritis and neuro-retinitis. When there is direct pressure upon the tracts and chiasm, the swollen papilla frequently appears of a peculiar gray-white color, without the evidences of much vascularity.

Other intracranial causes are softening of the brain, cerebritis, hemorrhage (very rare), thrombosis of the cavernous sinus, hydrocephalus (uncommon), and aneurism.

In rare instances myelitis is accompanied by optic neuritis.

In addition to the intracranial causes of papillitis, this phenomenon may arise as a symptom of: (1) Acute febrile affections—typhus fever, variola, scarlatina, diphtheria, etc.; (2) syphilis, both because of the formation of an intracranial product (gumma), or as an essential sign of the disease; (3) toxic agents, like lead; (4) anæmia, both when this is an essential process and when it is caused by excessive hemorrhage; (5) disturbances of menstruation; (6) exposure to cold, and rheumatism (sometimes monolateral); and (7) injuries. Papillitis occasionally occurs as a congenital affection in several members of the same family, and as an idiopathic disease without evident cause.

Finally those cases of neuritis arise which depend upon disease of the orbital region—inflammation of its contained tissues, tumors, caries, and periostitis, especially around the optic fora-

men, purulent disease of the antrum of Highmore and the frontal sinus, and morbid processes of the sphenoid and ethmoid bone. In most of these instances, unless both orbits are affected, the papillitis is unilateral, and there are other symptoms around the eye which point to the local condition.

A rare form of optic neuritis is that described in association with persistent dropping of a watery fluid from the nose. Headache, vomiting, unconsciousness, and delirium are present. The fluid has been believed to be identical with the cerebro-spinal fluid (Leber), or to be due to nasal disease in the form of small polyps (Nettleship and Priestley Smith).

Treatment.—This depends entirely upon the cause of the papillitis. In all syphilitic cases rapid mercurialization should be tried, followed later by the iodides. Indeed, in non-syphilitic cases, these remedies are often indicated for their alterative action. In anæmia, iron and arsenic should be exhibited; in rheumatism, the salicylates, iodides, and pilocarpine; in menstrual disturbances, measures for the promotion of the catamenial flow, if this has been suppressed. Orbital disease calls for appropriate surgical measures, and in high grades of papillitis, with distension of the optic sheath, several surgeons have exposed this, slit it, and evacuated the contained fluid, in the hope that thus a cause of mechanical compression would be removed.

Mechanism of Papillitis.—Ever since the days when von Graefe described optic neuritis as appearing in two forms—"neuritis descendens" and "Stauungs-papille" (choked disc), and meant by the former that condition which was originated by a descent along the optic nerve of inflammatory products from the seat of disease (*e. g.*, a basilar meningitis), and by the latter that condition which arose at the intraocular end of the nerve because the passage of blood returning from the eye was hindered by the increased intracranial pressure causing compression of the cavernous sinus (*e. g.*, a brain tumor), the stiff sclerotic ring at the same time affording mechanical obstruction—much study has been devoted to the relation of intracranial disease to optic neuritis. Graefe's theory ceased to be tenable when the demonstration was made that the free communication between the supra-orbital and facial veins nullified the influence of intracranial pressure on the cavernous sinus.

With the abandonment of Graefe's mechanical or "back-water" theory, new explanations were necessary, and the discovery that increased intracranial pressure caused dropsy of the sheath of the optic nerve, which usually is found on careful examination, by forcing the subarachnoid fluid along this sub-

Fig. 133.



Optic nerve and posterior portion of eyeballs *in situ* (the orbital plate has been broken in and the fat removed). The distension of the sheath of the optic nerve, especially on the left side, is noticeable as a swelling behind the sclera. The case was one of cerebellar tumor in a child four years old in the Children's Hospital.

vaginal space, led to the so-called *lymph-space* hypothesis, which, with various modifications, is still held by many observers to explain the mechanism most satisfactorily, especially when it is assumed on experimental evidence that certain irritating elements find their way from the neighborhood of the tumor to the bulbar end of the nerve, and there set up inflammation (Deutschmann). The hydrops of the nerve-sheath originates a compression of the optic nerve, and with it œdema and neuritis.

On the other hand, microscopical investigation shows that a tumor, as well as a basilar meningitis, may cause neuritis by the descent of an inflammation present in the neighboring membrane (localized meningitis), or surrounding tissue (cerebritis), along the optic nerve or its sheath. This inflammation becomes visible at the intraocular end of the nerve in the form of a

papillitis. The *résumé* of the subject given by Dr. Gowers, follows :—

"That in cases of cerebral tumor evidence of descending inflammation may be traced in sheath or nerve, much more commonly than current statements suggest, while in cases of meningitis the evidence of such descending inflammation is almost invariable.

That the resulting papillitis may be, and remain, slight, or may become intense and present the appearances of mechanical congestion. The causes of this difference we do not yet know.

That such mechanical congestion does not, as a rule, result from compression of the vessels in or just behind the sclerotic ring, but always, when intense, from compression by inflammatory products in the substance of the papilla. It must not be forgotten that an increase in the size of the vessels may be of reflex vaso-motor origin as in all inflamed parts.

That while slow increase of intra-cranial pressure has no effect on the retinal vessels, a sudden increase hinders the escape of blood from the eye for a time, and may intensify a papillitis originating in another way.

That distension of the sheath of the nerve alone is probably insufficient to cause papillitis by its mechanical effect, but may perhaps intensify the process otherwise set up, especially if the fluid possesses an irritative quality, and if (as Schmidt-Rimpler asserts and Leber denies) it can find its way into the lymphatic spaces of the optic disc.

There being thus little evidence that a mechanical impediment to the return of blood from the eye—induced either by intra-cranial pressure, by distension of the optic sheath, or by the pressure of the sclerotic ring—ever plays any considerable part in the production of optic neuritis, the use of the term 'choked disc' or 'Staungs-papille,' as indicative of a supposed mechanism, is to be deprecated in our present state of knowledge. The occurrence of a process of strangulation is not denied ; it is often conspicuous enough, but it is produced in the inflamed papilla and not behind the eye, and occurs in all cases of a certain intensity."

The many varieties of papillitis which occur independently of intra-cranial disease, indicate that the optic papilla is a structure prone to be inflamed.

II. Optic Atrophy.—Under the general term *atrophy of the optic nerve* are included the various types of degeneration and shrinking of the fibres of the optic nerve, usually described under the subdivisions *primary, secondary, consecutive* (*neuritic* or *post-papillitic*), and *retinal* and *choroiditic atrophy.* The last are really forms of consecutive atrophy.

Symptoms.—Certain general symptoms are common to optic atrophy, although these are subject to variations according to the clinical types.

(1) *Changes in the Nerve-head.* (a) *Alterations of the Normal Color of the Disc.*—The color of the disc varies from a slight gray pallor to a pure gray, greenish-gray, or entirely white hue. Many intermediate forms of discoloration occur; thus there may be a commingling of gray and red, producing the so-called "gray-red disc," and often there is a decided greenish tinge, rarely a blue one.

Much experience is required before deciding that change of color in the nerve-head is pathological, and a careful consideration of the age of the patient, the general complexion, the probable richness of the blood, the extent of the physiological cup, and the character of the illumination must be regarded. Grayness of the optic nerve will not always be apparent with ordinary methods of examination, especially when present in the deeper layers of the disc, but when examined by means of properly regulated illumination, and through a lens which neutralizes any existing error of refraction, this becomes manifest, and the appearance is then described as "a disc with superficial capillarity, but with gray deeper layers."

It is important to employ both the direct and indirect methods of examination, and the concave and plane ophthalmoscopic mirror.

(b) *Alteration in the Centre of the Disc.*—Sinking of the surface of the disc, varying from a slight depression to a complete excavation (page 366), occurs according to the degree of degeneration which the nerve fibres have experienced. The shape of the excavation depends somewhat upon that of the normal physiological cup, if this has been present. At the bottom of the atrophic excavation the mottling of the lamina cribrosa is very distinct in some cases of atrophy; in others, it is not apparent.

(c) *Alterations of the Margins of the Disc and of the Scleral Ring.*—In complete atrophy the margin of the optic disc is unusually distinct. In the atrophy which follows a neuritis or retinitis, however, the margins are often slightly veiled for a long time.

Undue broadening of the scleral ring indicates shrinking of the disc. Even in the early stages of spinal atrophies, the disc may be surrounded by a broad scleral ring, which, taken into consideration with alteration in the color of the papilla and contraction of the color field (especially red and green), affords diagnostic aid in the study of gray degeneration of the optic nerve.

(2) *Changes in the Vessels.*—In simple atrophy, while there may be narrowing of the vessels, this is not always the case, and certainly not in the manner seen in consecutive atrophies. Sometimes the arteries are narrowed and the veins unchanged.

In neuritic (consecutive) atrophy, the arteries are much contracted and the veins in contrast are larger than usual, often retaining some of the tortuosity which was so marked a feature during the papillitic stage. By the contraction of the tissue these, too, may later become narrowed. Development of white tissue along the course of the vessels, due to thickening of the peri-vascular lymph sheath is common in this form of atrophy.

In retinitic and choroiditic atrophy there is marked contraction of both veins and arteries, which at the same time are diminished in number.

(3) *Changes in the Surrounding Eye-ground.*—The presence of alterations in the general fundus depends entirely upon the cause of the atrophy. In simple gray and white atrophy such signs are absent; but in post-papillitic and retinitic atrophy spots of degeneration, marking the places of former hemorrhages, and patches of pigment-heaping, are commonly seen.

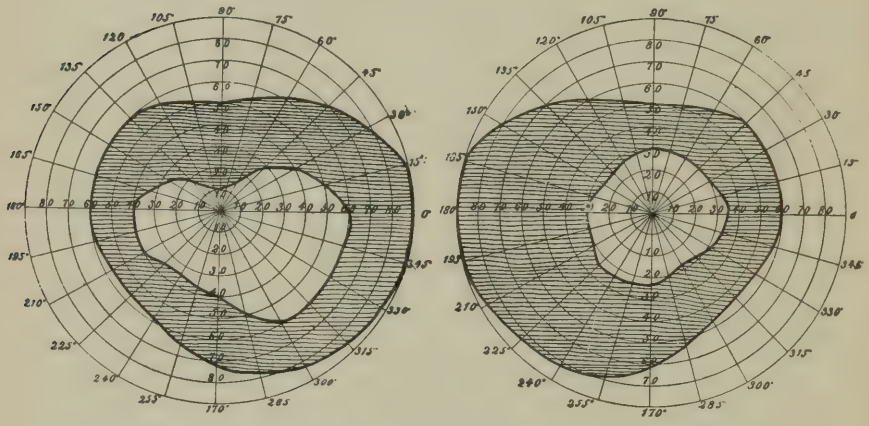
In addition to these ophthalmoscopic changes the following symptoms occur:—

(1) *Change in Central Vision.*—This varies from a slight depreciation to blindness, and, if the atrophy is bilateral, is more marked upon one side than upon the other. In every case, where this is possible, especially in early cases or cases of doubtful atrophy, a neutralization of any exciting refractive error should be made before deciding the degree of depreciation of central sight.

(2) *Change in the Field of Vision for Form (white).*—The following changes occur: Concentric contraction; very irregular

limitations presenting large reëntering angles (peripheral scotomata); quadrant-shaped defects; complete loss of one-half of the visual field (hemianopsia); and an abnormal blind spot in the centre of the field (central scotoma).

Fig. 134.



Right eye. Left eye.

Fields of vision in neuritic atrophy, exhibiting irregular concentric contraction. The shading shows where vision was lost.

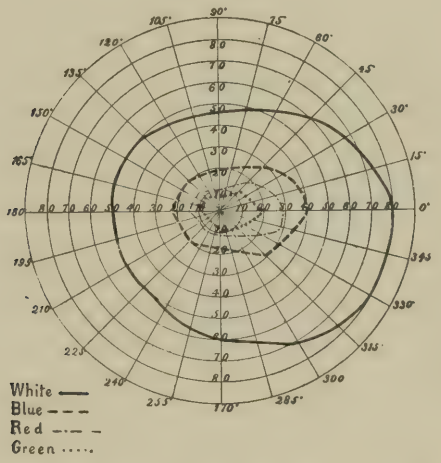
The field of vision, concentric restriction being most common, does not give evidence of the cause of the atrophy, although it may afford information of the localization of the defect; thus, an affection of the macular fibres will produce a central scotoma. In spinal atrophy the limitation more frequently begins at the outer side than in other situations.

(3) *Change in the Field of Vision for Colors.*—There is always a defect in color vision. Usually, there is first contraction of the green-field, then of the red, and afterwards of the blue and the yellow-field. The confusion and complete loss of central color vision occurs in the same way. Exceptions to this statement are found, and the perception of red may first feel the influence of atrophy.

Generally the contraction of the color-field is much greater than that of the form field (white). (Compare page 374.) Central

vision may be good, the form field but slightly or not at all affected, and yet the green and the red fields may be considerably contracted. Hence, the importance of combining all these examinations before deciding whether discoloration of the papilla is pathological or not.

Fig. 135.



Field of vision of the right eye in a case of optic atrophy. The form field is slightly contracted, the color fields markedly restricted. Compare figure 41, page 89.

(4) *Changes in the Pupil.*—The relations of the pupil to the action of light depend upon the degree of atrophy. Hence, in the majority of cases there is more or less perfect paralytic mydriasis, and when the atrophy is complete the pupil is dilated and the iris motionless. Even when the pupil fails to contract under the influence of light thrown upon the retina, it may do so in the act of convergence.

If the atrophy is confined to one side, no reaction will occur when the light falls upon the corresponding retina, but instant contraction takes place when this is directed upon the retina of the opposite (unaffected) side. In spinal disease (tabetic atrophy) certain changes in the pupil are seen, partly characteristic of this affection (page 67).

Varieties of Optic Atrophy.—1. *Primary atrophy* (sometimes called *gray*, *progressive*, *spinal* or *tabetic* atrophy).—The color of the disc is gray or white, sometimes with a greenish or bluish tint; the discoloration is associated with translucency, and the stippling of the lamina is evident; the excavation, if it exists, is complete and saucer-like; the vessels either are smaller than normal, especially the arteries, or they are unaffected in size; the edge of the disc is sharply marked, and the scleral ring clean cut all around. These symptoms describe the fully formed atrophy.

In the earlier stages of the degeneration, according to Norris, the discs are of a dull-red tint, their capillarity is superficial, and the deeper layers, in the neighborhood of the lamina cribrosa, are gray and wanting in circulation. There is often sufficient haze of the retinal fibres to veil the scleral ring. Later the nerve becomes pallid, is somewhat woolly superficially, and is surrounded on all sides by a broad and sharply cut scleral ring. The larger retinal arteries and veins do not at this stage present any appreciable change in their calibre or appearance. Both eyes usually are affected, one showing a further advance of the degenerative process than its fellow.

2. *Secondary Atrophy.*—The color of the disc may be gray and assume a tint not greatly dissimilar from the atrophy which has just been described. In other instances the color is more decidedly white. Both sets of vessels may be contracted, usually the veins being less affected than the arteries. In a certain number of cases of secondary atrophy it is probable that preceding the degenerative stage there is a transient congestion of the discs; certainly this is true in those cases where there has been a retro-ocular neuritis.

3. *Consecutive Atrophy.*—(a) *Post-papillitic Atrophy.*—The color of the disc is very gray or white, sometimes with a decidedly greenish tinge, or even a blue tint. It is noticeable, however, that the translucency present in the primary form of atrophy is absent, and the stippling of the lamina cribrosa is not visible, owing to the existence of a non-transparent tissue which covers it. The borders of the disc are slightly veiled, and the peri-vascular lymph-sheaths are thickened. The arteries are

contracted, the veins frequently exhibiting distinct tortuosity. Retino-choroidal changes are often evident.

(b) *Retinitic and Choroiditic Atrophy.*—This is in the form of atrophy of the nerve to which reference has already been made, and which follows violent forms of retinitis and choroiditis. The color of the disc is characterized by having a distinctly yellowish tinge, being somewhat waxy in appearance; its borders are not sharply marked; and the vessels are narrowed, often to a great degree.

Causes.—In addition to the forms of atrophy which follow inflammation of the nerve (*post-papillitic*), inflammation of the choroid and retina (*choroiditic* and *retinitic* atrophy), embolism and thrombosis of the central artery and central vein of the retina (*embolic* atrophy), the etiology of those examples that are gathered under the general terms *primary* and *secondary* atrophy require mention.

Gray degeneration of the optic nerve occurs, in the great majority of instances, under the influence of diseases of the spinal cord, especially locomotor ataxia. It is also seen in general paralysis of the insane, insular sclerosis, and lateral sclerosis. There is some difference of opinion in regard to the frequency of optic atrophy in locomotor ataxia, but an average of a number of observations gives 33.7 per cent. of atrophies. In most instances it begins in the pre-ataxic stage.

Primary atrophy has also been ascribed to the influence of cold, imperfect nutrition, disturbed menstruation, and venereal excesses. There is little doubt that in certain instances it is due to chronic malaria, diabetes, and syphilis.

A very remarkable type of primary atrophy appears to be distinctly hereditary, affecting especially the males of a family. (Leber, Norris.) This has been referred to under Optic Neuritis, because it is probable that in many of the instances there is a preceding congestion or low-grade inflammation of the disc.

Finally, there are instances of optic atrophy which can be ascribed to no very definite cause.

Secondary atrophy appears under the influence of compression of the optic tract and the optic fibres; for instance, by bulging of

the lateral ventricles, pressure of a tumor, exostosis, or aneurism (Mitchell) upon the chiasm. It is also said to occur with meningitis without preceding neuritis. Any compression around the optic foramen is likely to produce a secondary atrophy by direct injury to the fibres of the optic nerve, just as in other instances it may produce a neuritis.

Blows on the head produce atrophies. This has been noted after injuries in the neighborhood of the supraorbital foramen. The author has seen two such instances without a fracture of the orbital plates; periostitis, however, was probably present.

Finally, there is a series of atrophies resulting from an inflammation of the axis of the nerve back of the ball.

Diagnosis.—The diagnosis of optic atrophy rests upon a consideration of the symptoms already detailed. The student is particularly warned not to mistake the pallor of age for the pallor of disease; not to mistake a large physiological cup, with its margin shelving toward the temporal border of the disc, for an atrophy confined to half of the optic papilla; not to mistake a posterior staphyloma, which may surround the entire disc, for an atrophy; and not to mistake small patches of retained marrow sheath for atrophic changes.

Not every gray disc, with an unusually marked scleral ring, is indicative of atrophy, and it is only when these appearances accord with the other manifestations of beginning degeneration that the diagnosis of incipient atrophy is justified.

The differential points between a chronic glaucoma and an optic atrophy have been described (page 378), and also the relation of light-sense to optic atrophy.

Course and Prognosis.—The course of optic atrophy is always a slow one, lasting for months and it may be years, depending to a certain extent upon the original cause of the atrophy.

The prognosis is unfavorable in primary, or, as it is sometimes called, progressive atrophy, the tendency being to a gradual deterioration of sight with shrinkage of the field of vision, until complete blindness is the result. The prognosis of a consecutive atrophy depends entirely upon the amount of damage which is likely to ensue from the shrinking which follows during the subsidence of the neuritis. In the forms of atrophy

which follow an inflammation of the axis of the nerve, the prognosis is better.

In making up a prognosis it is necessary to examine not only central vision, but also the field of vision. Sometimes the former remains stationary while the latter progressively contracts, and under these circumstances false information would be given unless both examinations were undertaken.

TREATMENT.—This depends upon the cause of the disease. If there is reason to suspect syphilis, the usual remedies are indicated, especially, it seems to the writer, a prolonged course of bichloride of mercury. In other instances nitrate of silver has been found useful, and in a few examples suspension is said to have been followed by improvement in vision, in tabetic atrophy.

Probably the most generally useful remedy in optic atrophy is strychnia, and under its influence central vision improves and the field of vision widens out. It should be administered in full doses, and the hypodermic method affords the best results. Other remedies, according to the cause of the atrophy, are iron, arsenic, and phosphorus. Santonin was at one time recommended in some types of optic atrophy, but the results from it have never justified its continued exhibition. Finally galvanism has been advised, and competent observers have reported good reeults from its use.

Orbital Optic Neuritis[1] (*Retro-bulbar neuritis; Central amblyopia; Toxic amblyopia*).—In contradistinction to the optic neuritis which is specially localized at the intraocular end of the nerve, an inflammation occurs in the orbital part of the optic nerve, which is called *orbital optic neuritis*, or *retro-bulbar neuritis*. It appears in an *acute* and a *chronic* type.

(1) *Acute Retro-bulbar Neuritis.*—The ophthalmoscope reveals a moderate degree of retinal congestion and blurring of the edges of the optic disc; the arteries are small; the veins enlarged and somewhat tortuous.

The sight is greatly impaired, and may be so much affected

[1] Dr. Knapp's paper on "Orbital Optic Neuritis, Including Alcohol and Tobacco Amaurosis," published in the Archives of Ophthalmology, January, 1891, has been freely utilized in the preparation of this section.

that there is complete blindness, although this is rare. The peripheral field of vision is unaffected, or at least not greatly contracted, but there is a central scotoma which may be either positive or negative. Color perception is subnormal.

CAUSE.—This affection has been attributed to the influence of certain toxic agents such as alcohol, lead, nicotine, etc.; to menstrual disturbances, especially sudden suppression of the menses; to rheumatism; to measles, diphtheria, scarlet fever and other acute infectious diseases; and to over-work. A certain number of cases exist for which no cause can be ascertained.

The *course* of the disease may be moderately rapid, or it may last for a long time, ending in a restoration of the normal composition of the nerve, or leading to partial or complete atrophy. For this reason the *prognosis* must always be guarded. One or both eyes may be affected, and sometimes a long interval occurs between the affection of the first and of the second eye.

TREATMENT.—The patient must be removed from the influence of any supposed cause. If the affection has occurred during the course of an acute infectious disease, the treatment of this particular malady is indicated. Under other circumstances the best results follow pilocarpine-sweats, full doses of salicylic acid, the free use of mercury, and the iodides.

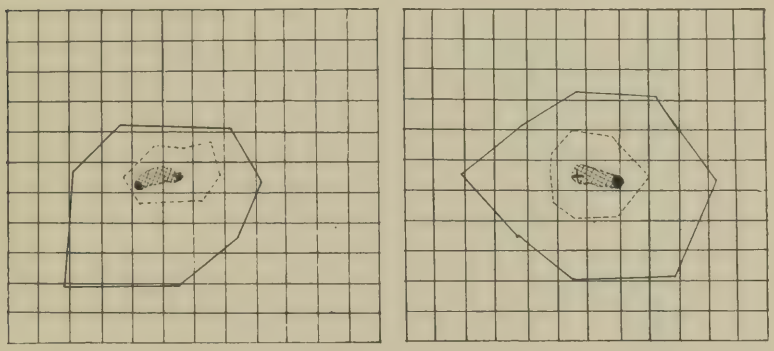
(2) *Chronic Retro-bulbar Neuritis.*—This is the form of the disease which is very often called *tobacco amblyopia*, or *toxic amblyopia*. It may not be possible to detect any abnormal condition in the face of the optic nerve, or at most only a slight veiling of its edges and discoloration of its surface ("dirty-disc"), or there is a *quadrant-shaped atrophy* in the lower and outer part of the disc, or finally, if it is at a late stage of the disorder, general atrophy.

The patients complain of diminution of sight which cannot be improved by the use of glasses, vision being better in a dull light than in the bright glare, owing probably to slight hyperæsthesia of the retina.

The color perception is diminished, the peripheral boundaries of the visual field are normal, and there is a central color-scotoma, especially for red and green, which is usually oval in shape, and is situated between the point of fixation and the blind

spot. These colors are not recognized in their true character in this area; green appears dirty white; red, brownish. Finally the scotoma becomes absolute; *i. e.*, it exists for form. Before deciding that there is a scotoma for red and green, the examiner should

Fig. 136.



Diagrams illustrating the positions of color-scotomas in the field of vision, mapped on a black-board, in a case of so-called tobacco amblyopia. The continuous line indicates the peripheral limits of the form field, the dotted line the red field, and the oval dark area the scotoma.

be sure that there is no red-green blindness. Under these circumstances he would be obliged to make use of blue and yellow, and under any circumstances it is well to employ these colors in the test.[1]

Causes.—In a large majority of the cases just described the name "tobacco amblyopia" is justified by the fact that the disease occurs for the most part in men whose clinical histories show that they have abused tobacco, generally in conjunction with alcohol, some observers believing that pure tobacco amblyopia does not exist. Certainly in one instance in the author's practice, where the scotoma assumed a ring form, there was absolutely no history of the use of alcohol. Although usually bilateral, a few instances have been recorded in which the symmetrical devel-

[1] Berry has found decided light-sense defect in abnormal states of the macular fibres of the optic nerve, and suggests this test as a means of diagnosticating forms of retro-bulbar neuritis, in which the central scotoma has not developed.

opment of tobacco amblyopia has been delayed. It is rare before the thirty-fifth year.

A chronic retro-bulbar neuritis can also be caused by lead, carbon bisulphide, and opium. It has been attributed to syphilis, diabetes, rheumatism, gout, and influenza.

The pathological lesion which causes this form of amblyopia is an interstitial inflammation of the *papillo-macular* fibres of the optic nerve. These fibres, traced by means of their degeneration, consist of a bundle shaped like a triangle near the eye, with its base in the lower and outer part of the nerve, and its apex at the central vessels. Gradually it passes to the centre of the nerve, which it reaches in the optic canal. Finally it can be followed into the chiasm and tracts. Retro-bulbar neuritis is really a form of peripheral neuritis.

Course and Prognosis.—The course is, as its name indicates, a chronic one, but the prognosis of the tobacco and alcohol cases is good, provided they present themselves at an early enough stage for treatment.

Treatment.—This consists in total abstinence from the use of tobacco and alcohol, and in the earlier stages this alone will be sufficient to bring about a cure. Later the best remedy is strychnia. which, as in other instances of optic nerve disease, should be pushed to its full physiological limit. In order to help in the absorption of inflammatory products iodide of potash may be given; certainly if there is any reason to suspect syphilis. In addition to this regulation of diet, rest and an occasional free diaphoresis are valuable adjuvants. Temporary improvement occurs under the influence of inhalations of nitrite of amyl, and the circulation of the optic nerve may be stimulated by the exhibition of digitalis and nux vomica.

Injury of the Optic Nerve.—This may occur by the entrance of a foreign body into the orbit, like the end of a sharp stick, or from a fracture involving the bony wall of the orbit or base of the skull. Atrophy of the optic nerve is the result.

Tumors of the Optic Nerve.—These are of rare occurrence, about seventy cases having been recorded, and include fibroma, sarcoma, glioma, and myxoma.

The *symptoms* are: Exophthalmos, the eye being pushed down-

ward and forward, the motions of the globe being unaffected; and defective vision, which is an early manifestation. The growth is slow and painless, but sometimes a suppurative keratitis may result. The ophthalmoscope reveals distended veins, œdema and inflammation of the papilla, followed later by white atrophy and shrinking of the vessels.

TREATMENT.—In a few instances the tumor has been excised without removal of the eyeball, but in most cases enucleation has been necessary, the nerve being severed far back so as to include the entire growth.

CHAPTER XVII.

AMBLYOPIA, AMAUROSIS, AND DISTURBANCES OF VISION WITHOUT OPHTHALMOSCOPIC CHANGES.

Amblyopia and amaurosis both signify *dimness of vision*, the former being used to describe *obscurity of sight*, and the latter the more advanced condition of *loss of vision*. Although these terms are usually applied to cases in which no changes are visible in the eye, this limitation is not strictly followed, and eyes blinded by inflammatory disease are sometimes described as *amaurotic*.[1]

Modern methods of examination have greatly lessened the number of instances in which the older writers applied the words "amblyopia" and "amaurosis." Amblyopia is a symptom and describes the defective vision from which the patient suffers. This may be due to functional disturbance or to disease of the visual apparatus (retina, optic nerve, or visual centres), and may be unassociated with changes in the eye-ground; or there may be atrophy of the optic nerve.

Amblyopia may be congenital or acquired; temporary or permanent; and symmetrical or non-symmetrical.

Congenital Amblyopia.—This name is applied to instances of defective vision for the most part uncomplicated with fundus lesions. The faulty vision has always existed, and often high grades of hypermetropia and astigmatism are present, and clear images have never been focused upon the retina. Correction of the optical error fails to produce normal or even nearly normal vision; the retinal images continue to be defective. In quite young patients an eye of this character may occasionally be trained to more perfect vision after a proper correction of the

[1] The term amaurosis is also applied to certain cases of blindness in young children dependent upon hereditary influence, syphilis, tubercular disease and meningitis. The eye-grounds may or may not be diseased.

refractive error has been made. Sometimes the defect is not discovered until late in life, and then no optical treatment is of avail.[1]

Defective vision, attributed to lack of use (*amblyopia ex anopsia*), may occur on account of obstruction to the rays of light falling upon the retina; *e. g.*, congenital corneal opacities, congenital cataract, and impervious persisting pupillary membrane; or in an eye which from earliest infancy has squinted, thus not being concerned in the visual act (compare with page 531).

Gould maintains that certain cases of amblyopia which have been attributed to disuse are really due to a low grade of choroido-retinitis affecting the macular region, brought into existence by an irritating stimulus with which a long-continued ametropia has supplied this area.

In this category of amblyopias are also placed certain congenital defects of structure; *e. g.*, coloboma of the iris and deficient development of the entire eye (microphthalmos). Retinal hemorrhages in the newly born explain some cases. Usually one eye is affected; if both are amblyopic nystagmus commonly is present. Squint may be developed when a single eye is amblyopic.[2]

Congenital Amblyopia for Colors (*Color-Blindness*).—Congenital disturbance of the color-sense has been found in about 3 per cent. of the examinations made for this purpose, but it is extremely rare in women (0.2 per cent.). Both eyes, except in

[1] A form of amblyopia has been described dependent upon an imperfect development of the functions of the finer anatomical elements of the retina, the rods and cones. It has been attributed to the fact that at the time of the education of the sense of sight, owing to astigmatism, the retina has been asymmetrically stimulated, and consequently there has been asymmetry of visual acuity. To this condition Martin has given the term *astigmatic amblyopia*, and from it the important lesson is learned that in order to educate the sense of sight properly even moderate degrees of astigmatism should be corrected at an early age.

[2] A persistent cramp of the lid, such as occurs in children, unrelieved for weeks at a time, may produce blindness, noticed when the eyes are finally opened, temporary in its character with normal ophthalmoscopic appearances. In other cases the loss of vision, however, is permanent, with gross changes in the eye-ground. This condition has been referred to under the caption of blepharospasm (page 205).

rare instances, are affected, and a distinct hereditary tendency has been noted in many instances. In other respects the functions of eyes which are "color-blind" are normal, and the cause of the condition has not been determined.

Derangements of the perception of colors have been divided into two varieties: the one characterized by an absence of the power to perceive colors, or *achromatopsia;* and the other characterized by difficulty in distinguishing colors, or *dyschromatopsia.* The former condition, or color-blindness, is rarely *total* as a congenital defect (a condition which is not uncommon as the result of pathological changes in the optic nerve, etc.); generally it is *partial; i. e.,* one or more of the fundamental colors are not recognized.

According to different theories of the perception of colors, partial achromatopsia is divided into green, red, and violet blindness, or into "red-green" and "blue-yellow blindness," and the latter is the more convenient classification. The most usual manifestation is red-green blindness, or that in which the individual confuses with a pure green shades of gray and red; the other type, or blue-yellow blindness, is not common.

In the second variety, or imperfection in the color-sense, the individual may correctly recognize brightly marked colors, but becomes confused in colors closely allied and in the various shades. To him violet and blue, and orange and red, are difficult distinctions. Dyschromatopsia should be distinguished from partial achromatopsia. (Landolt.)

The methods of detecting color-blindness have been described on page 70. Congenital color-blindness must not be confounded with the various disturbances of the color-sense which result from diseases of the optic nerve and retina, or with those which are seen in hysteria. No treatment is of avail.

Reflex Amblyopia.—Certain cases of partial or complete loss of vision have been vaguely attributed to irritations in distant portions of the body; for instance, the presence of parasites in the intestinal canal. In many of these instances, however, a proper investigation has shown that other causes have been active in producing the defective sight.

A number of well-established cases are on record in which an

irritation through the branches of the fifth nerve has produced an amblyopia, chiefly with disease of the teeth. At all events, in any case of amblyopia unattended with ophthalmoscopic changes, and not readily classified in any of the groups, a thorough examination of the teeth is advisable.

Traumatic Amblyopia.—This may occur after severe injuries to the head, especially in the occipital region; bruises along the course of the spinal cord after a railroad injury; and blows upon the brow in the region of the supraorbital nerve.

In some of the cases there is either a fracture of the skull, a hemorrhage into the intracranial cavity, or some disorganization of the brain contents, followed by secondary changes in the optic nerve. In other instances no ophthalmoscopic changes are discovered, and the defective vision may be temporary in character. Amblyopia, after railroad injuries, is sometimes enormously exaggerated by patients in the hope of securing damages.

The *treatment* of a traumatic amblyopia, provided there is no gross lesion such as atrophy, hemorrhage, or an œdema of the retina (*commotio retinæ*), is rest, until there is proper recovery from the injury, and the use of strychnia, especially hypodermically.

Amblyopia and amaurosis occur under the influence of disease and the toxic action of certain drugs, due either to a direct effect upon the retina, to an influence upon the visual centres, or to some change, perhaps of vaso-motor origin, affecting the blood supply of these structures.

In this category may be noticed:—

(1) **Uræmic Amblyopia, or Amaurosis.**—This is seen almost always with scarlet fever and pregnancy. In scarlet fever it appears with albuminuria in the stage of desquamation, and is bilateral, the blindness in many cases being absolute and often associated with brain-symptoms: convulsions, vomiting, stupor, coma, and hemiplegia. In spite of the total blindness a characteristic symptom is the preservation of the pupillary reactions.

The ophthalmoscope picture may be negative, or there is a slight neuritis, or a little woolliness of the surface of the optic disc.

The *prognosis*, as far as the return of vision is concerned, is good.

The *treatment* does not differ from that which is applicable to the disease which produced it.

(2) **Glycosuric Amblyopia.**—In addition to the affections of vision already described in connection with diabetes (cataract and retinal hemorrhages), there occurs an amblyopia in this disease in which the visual field is sometimes intact, sometimes peripherally restricted, occasionally hemianopic, but in which there is a color-scotoma, and, moreover, in cases not addicted to the use of tobacco or alcohol. The amblyopia may be the only symptom of diabetes, and in any unexplained case the urine should be examined for sugar, a practice which is necessary if color-scotomas are found, even if a history of the abuse of tobacco is obtainable.

The prognosis is unfavorable, and the treatment, which should include the usual measures suited to diabetics, is not very efficacious.[1]

(3) **Malarial Amblyopia.**—In addition to the amblyopia in malarial cachexia with lesions apparent at the bottom of the eye-grounds, are those cases, without such lesions, due to a special action of the malarial poison upon the optic nerve and the retina. These appear in the form of a transient loss of vision, or as complete blindness, lasting from several hours to some days or even months. The affection disappears under anti-periodic treatment. In most of the instances ophthalmoscopic findings are negative, or the descriptions are included in vague terms applied to the retina and optic nerve—"congestion," "hyperæmia," and "redder than normal." The affection may be unilateral or bilateral.

(4) **Amblyopia from Loss of Blood.**—Loss of sight often follows hemorrhage, more frequently when this is spontaneous than after a traumatism, and is said to be most complete after hemorrhage from the stomach.

Two very different results may ensue: Either a temporary blindness, owing to the impoverished blood supply of the visual centres or retina, or a permanent loss of sight and atrophy of the optic nerve.

[1] The student interested in the diabetic eye affections should consult Hirschberg, Deutsch. med. Wochenschrift, March 26, 1891, and Moore, New York Medical Journal, March 31, 1889.

The ophthalmoscopic appearances vary from a slight pallor to complete atrophic whiteness of the papilla, with contraction of the arteries. The lesions in the unfavorable cases usually do not appear until a week or more after the hemorrhage has taken place. Neuritis, and hemorrhages into the retina, may also arise. The prognosis is most favorable in uterine cases.

The *treatment* consists in the use of iron, arsenic, and strychnia, complete rest and an easily assimilated diet.[1]

Amblyopia from the Abuse of Drugs.—A certain number of toxic agents (lead, tobacco, alcohol, etc.) produce an axial neuritis with great loss of vision, and these have been described under the general term *orbital optic neuritis* (page 473).

Amblyopia, more or less complete, may arise under the toxic influence of nitrate of silver, mercury, bisulphide of carbon, nitrobenzol, salicylic acid, and lead. The last agent may produce a neuritis (either intraocular or orbital), but also an amblyopia without ophthalmoscopic changes. It is usually transient, occurs in acute cases, and has been compared by Gowers to the temporary amaurosis of uræmia.

The loss of vision which occurs under the influence of quinine deserves special mention. It usually is called *Quinine Amblyopia*, or *Amaurosis*. Although in most instances quinine blindness follows the ingestion of a large quantity of the drug, occasionally the symptoms appear with moderate doses. The author has seen twelve grains produce decided temporary amblyopia in a susceptible and neurotic woman.

The characteristic clinical features of quinine amaurosis are total blindness subsequent to taking large doses of the drug, extreme pallor of the optic discs, marked diminution of the retinal bloodvessels in number and calibre, and contraction of the field of vision. Other symptoms which have been noted are: diminution of the color- and light-sense, dilated pupils and immobile

[1] In addition to the amblyopias without ophthalmoscopic changes, seen with the diseases already mentioned, others, less commonly observed, could be included. For example, sudden blindness with preserved pupillary reaction and without ophthalmoscopic changes has been noted with whooping-cough, and is probably due to central œdema between the corpora quadrigemina and occipital lobes.

iris during the blind stage, and occasionally anæsthesia of the cornea. Usually the effect of quinine upon the ear is manifested by deafness and tinnitus.

The restoration of central vision may be perfect, or incomplete. The contracted field of vision gradually widens out, but does not regain its normal limits. The disc may remain pallid and quite atrophic-looking years after the poisoning; in other instances it resumes its normal tint. In one case (Gruening) a cherry-colored spot was noted in the macula.

The exact mechanism of quinine blindness is not known, but probably depends upon a species of œdema between the optic nerve, chiasm, and eyeball, associated with the influence of quinine upon the vaso-motor centres, tending to excessive constriction of the peripheral circulation, and the final production of local changes in the vessels (endo-vasculitis). The author has experimentally shown that toxic doses of quinine in dogs may cause permanent optic atrophy and thrombosis of the central vein of the retina.

The *treatment*, in addition to the discontinuance of the drug, consists in the administration of nitrite of amyl, which will cause temporary improvement, and the exhibition of strychnia and digitalis.

Hysterical Amblyopia.—Hysterical blindness usually occurs in young girls and women; but both males and females may be affected. The loss of vision is complete, almost always monolateral, and the pupil reacts promptly to light when the sound eye is covered. The ophthalmoscopic appearances are normal. Quite commonly it is possible to prove by the usual tests that the supposed blind eye really sees (page 485).

In addition to monocular blindness there is a large group of cases in which achromatopsia or dyschromatopsia, contraction of the field of vision, and hemianæsthesia constitute the symptoms. Sometimes, instead of simple contraction of the field of vision, there is hemianopsia. The defect of vision may occur in the form of *crossed amblyopia*, *i. e.*, complete or partial blindness on the same side as the hemianæsthesia, and associated with some deficiency of acuity of vision upon the opposite side.

Not only may there be partial or complete color blindness in

hysteria, but also a more or less perfect reversal of the order of the colors as they normally appear. In a series of cases studied by Dr. John K. Mitchell and the author, this phenomenon was well shown. No other ocular manifestations were present.

Hysteria produces many other remarkable functional disturbances of the eye—ptosis, blepharospasm, conjugate deviation of the eyes, and the great symptom-group gathered under the term "retinal asthenopia"—which do not properly belong to this category.

The *prognosis* of these cases in the main is good, although the blindness may last for long periods of time.

The *treatment* consists of measures calculated to improve the condition of the patient, massage, rest, electricity, and tonics.

Pretended Amblyopia (*Malingering*).—For the purpose of escaping irksome duties, for example in the army, or to excite sympathy, patients will occasionally pretend to be blind in one eye. In order to detect the deception many plans have been originated. Two methods will be described:—

(1) *The Diplopia Test.* — This is performed in the same manner as the ordinary examinations of the external ocular muscles with prisms. The subject is seated before a lighted candle at twenty feet distance, and a 7° prism placed before the admittedly sound eye. If, now, superimposed double images are acknowledged, there is binocular vision, and the fraud is detected. The examiner may vary the test by placing the prism before the supposed blind eye, either base up or base down.

(2) *Harlan's Test.*—This is an extremely useful and simple device, and is performed as follows: Place an ordinary trial frame upon the subject's face and put before the admittedly sound eye a high convex glass (+ 16 D), and before the eye which is claimed to be blind a plain glass or a weak concave spherical (—25 D), which will not interfere with vision. If letters placed at a distance of six metres are read, the act of reading must have been done by the eye which was claimed to be sightless, inasmuch as vision at that distance with the other eye is excluded by the presence of the high convex lens. The test may be further elaborated by covering the pretended blind

eye and requesting the patient to read the letters; if he is unable to do so, the fraud is at once exposed.

If a malingerer claims to be blind in both eyes these tests will not avail, and he can be detected only by placing a careful watch over him.

The fact that the pupil contracts on exposure to light does not prove that there is sight in the eye, because, as Swanzy points out, a lesion in the centre of vision, or in the course of the fibres connecting this centre with the corpora quadrigemina, producing absolute blindness, would still permit a perfect reaction of the pupil to light.

Night-blindness (*Functional night-blindness;* often incorrectly termed *hemeralopia*, but properly *nyctalopia*).—It has already been pointed out that night-blindness is one of the early and characteristic symptoms of pigmentary degeneration of the retina. In the present condition, however, no morbid changes are revealed by the ophthalmoscope.

It is a functional complaint, consisting in a diminished sensibility or imperfect adaptation power of the retina (Treitel), due, apparently, to exposure of the eye to strong light, together with a debilitated and often scorbutic state of the system. It affects residents in tropical countries, often soldiers and sailors, and has been occasionally observed in large schools, usually in the early spring or summer (Nettleship, Snell). It prevails as an endemic in certain countries, especially in Russia during the Lenten fasts.

The patients, in addition to their inability to see well in the dusk or even on dull days, although their vision is good enough in a bright light, often suffer from one of the forms of xerosis conjunctivæ (epithelial xerophthalmos, see page 249).

Treatment.—This includes the administration of iron, strychnia, and cod-liver oil, according to the indications. Dark-colored glasses should be worn. If scurvy is present, the diet and remedies suited to this condition should be prescribed.

Day-blindness (often incorrectly termed *nyctalopia*, but properly named *hemeralopia*).—This is an affection, or rather a symptom, as the name implies, characterized by the fact that its subjects see better on dull days and in the dark than in a bright light. The visual field is not concentrically contracted.

This symptom occurs with the condition described by Arlt as *retinitis nyctalopia*, and with orbital optic neuritis of the chronic type (tobacco amblyopia, page 474). It also occurs in other affections of the optic nerve and in some diseases of the retina. The same condition may be present with certain congenital anomalies—albinism, coloboma of the iris, and irideræmia. It also occurs as an idiopathic affection, and may develop in those who have long been excluded from the light. It may also be congenital, and may be associated with an amblyopia of like origin.

A tonic *treatment* should be tried and the retina gradually educated to sustain bright light.

Snow Blindness.—As this ordinarily is seen in northern regions, it is an affection of the conjunctiva. There are burning pain, photophobia, blepharospasm, hyperæmia of the conjunctiva, and chemosis. In severe cases there may be ulceration of the cornea. The pupils are small, and there is congestion of the retina. The visual acuity may be unaffected, or it may be distinctly lessened, especially if corneal complication coexists. The dazzling of the snow may cause restriction of the field of vision, scotoma, and night-blindness,[1] but when the sun shines, the heat reflected from the surface of the snow produces an erythema of the conjunctiva. If the sunshine is absent, a mechanical cause is found in small flying particles of snow and ice (A. Berlin). Prolonged exposure to powerful electric light may produce somewhat analogous symptoms.

Erythropsia, or Red Vision.—Colored vision in glaucoma (iridescent vision), in the form of variously tinted halos about the lamp lights, has been described, and patients with blind eyes occasionally complain of being conscious of colored lights, owing probably to some irritation of the visual centres.

Erythropsia in most instances has been noted after cataract extraction. Visual acuity is not affected, but everything appears of a red or violet color. Bromide of potash is indicated, and is said to ameliorate the symptom.

Micropsia and **Megalopsia** have been described in connection with syphilitic retinitis. They may appear as a functional disorder in hysterical cases.

[1] The opposite condition, day-blindness, has been reported.

CHAPTER XVIII.

AMBLYOPIA OF THE VISUAL FIELD, SCOTOMAS AND HEMIANOPSIA.

THE importance of perimetric measurements in the study of various forms of ocular disease, especially in glaucoma and in affections of the retina, choroid, and optic nerve, has been noted. (For the methods of examination consult Chapter II.) There remain to be considered certain conditions in which a defect in the field of vision constitutes one of the most prominent symptoms.

I. Partial Fugacious Amaurosis (*"Flimmer-scotom"*).—The symptoms are: A sense of vertigo; a positive darkening of the field of vision of each eye, beginning at the centre and widening out in a vibratory movement until it overspreads the field, with corresponding sinking of the central acuity of sight; and cessation of the amaurosis with the onset of headache and vomiting. It may then be a prodrome of hemicrania, but is also seen without it, and may occur in syphilitic subjects. The condition probably depends upon circulatory disturbances in the occipital lobes.

The *treatment* is directed toward the headache, the partial amaurosis being exceedingly temporary in character, and includes the measures suited to migraine. Syphilis calls for the usual remedies.

II. Amblyopia of the Visual Field (*Anæsthesia retinæ*).—This functional disturbance as part of a general neurosis has been described on page 417. Because of the peculiar changes in the visual field many authors prefer the name "amblyopia of the visual field" to that of "anæsthesia of the retina."

Somewhat analogous restrictions of the visual field are seen after injuries, and with *traumatic anæsthesia* of the retina; in the latter condition the element of hysteria cannot always be eliminated.

III. Scotomas.—Any lesion which blots out the function of a portion of the retina produces a corresponding blind area in the field of vision, or a scotoma, for example a hemorrhage, a patch of retino-choroiditis in the macular region, or spots of disseminated choroiditis in the periphery of the eye-ground. Papillitis causes an enlargement of the natural blind spot. (Consult figure 132). In chronic glaucoma, scotomas may lie in the centre of the field, or at its more peripheral parts, and sometimes assume a ring shape. Unilateral scotomas may occur in hysteria, with menstrual disorders, and in partial embolism of the central artery of the retina.

In addition to these diseases certain affections of the optic nerve are accompanied by a scotoma.

Following the classification of Jensen, these may be described as :—[1]

(a) *Central Amblyopia with Scotoma* (*Toxic Amblyopia*).—This affection has been described on page 473.

(b) *Stationary Optic Atrophy, with Scotoma.*—This is characterized by a scotoma, similar to the one which occurs with toxic amblyopia, but much more decided. There are marked diminution of central vision, a depreciation of the color sense, and ophthalmoscopically the appearances of optic atrophy. The process is stationary and vision does not improve under treatment. Jensen finds this affection exclusively in men before their thirty-fourth year. It has a hereditary tendency, and is said to be caused by exhaustion and lack of sleep. Sometimes no cause can be demonstrated. Preceding the atrophy there may be slight neuritis.

In the cases of *hereditary atrophy* of the optic nerve recorded by W. F. Norris, the ophthalmoscopic changes commenced with a stage of cloudy swelling of the disc and passed on to a gradual death of the nerve. The disease began with a central scotoma, first for color, but gradually this became complete. Both the males and females of the family were affected.

(c) *Progressive Optic Atrophy, with Scotoma.*—This includes the class of cases in which the optic atrophy of spinal disease

[1] A translation by Mr. G. A. Berry of a lengthy abstract of Jensen's article on "Diseases of the Eye accompanied by a Central Scotoma" appears in the Ophthalmic Review, January, 1891.

(tabes dorsalis) is associated with a scotoma. The scotoma is central and shaped like the one in tobacco amblyopia, but as the disease progresses the peripheral field begins to contract, and finally it becomes difficult to detect the central defect. It is by no means common to find a central scotoma in tabetic atrophy of the optic nerve.

(d) *Optic Neuritis, with Scotoma.*—An unusual symptom of intraocular neuritis caused by meningitis is a central scotoma, either relative or absolute. The student should not confuse this with an enlargement of the natural blind spot due to the inflammatory swelling of the nerve-head.

As has already been pointed out, the cause of central scotoma in orbital optic neuritis (tobacco amblyopia) is an inflammation of the papillo-macular bundles in the optic nerve. Whether a partial affection of the optic nerve will explain all cases of central scotoma remains to be seen, and Jensen suggests that a common central cause may be active.

IV. Obscuration of One-half of the Visual Field, or Hemianopsia.[1]—In diseases of the eye, *e. g.*, glaucoma, one-half of the visual field may be wanting, and also in cases of optic atrophy and neuritis, even when unconnected with disease of the visual pathway. These cases, however, are not included in the present account.

Hemianopsia is that defect of vision characterized by an obscuration, usually in each eye, of one-half of the field, which occurs under the influence of a lesion situated at the optic chiasm, in the visual tract, or at its ultimate destination in the brain (occipital lobe).

Visual Tract.[2]—The visual tract or pathway proceeds from the retina to its final termination in the brain, as follows:—

[1] The terms *hemiopia* and *hemianopsia* are often used synonymously. Really, hemiopia signifies loss in the perceptive power of one-half of the retina, while hemianopsia means obscuration of one-half of the visual field (Seguin). Other names which are used are hemianopia and hemiablepsia.

[2] The description of the visual tract is condensed from Dr. Henry D. Noyes's paper on Hemianopsia (New York Medical Record, April 4, 1891). This should be studied in connection with Dr. Hermann Wilbrand's monograph, "Die Hemianopischen Gesichtsfeld-Formen und das Optische Wahrnehmungszentrum," by those students who desire to read the best account of the subject of hemianopsia.

The peripheral percipient elements in the retina are the rods and cones, which are connected by fibres with the outer and inner granule layers, but in the region of the *macula lutea* they are finer and anastomose freely, and they cannot, as elsewhere, be separately traced.

The macular fibres are gathered into a triangular bundle composing about one-fourth of the nerve, which enters the *papilla* at its infero-temporal side. As it pursues its way through the *orbital portion*, it gradually approaches the axis of the nerve, which it reaches in the *optical canal.*

At the front of the *chiasm* it occupies its upper and inner portion, but in the *tractus* it sinks to the central portion and remains there until it arrives at the brain. In the chiasm the fibres of the optic tract undergo a semi-decussation.[1] The papillo-macular bundle is likewise divided into crossing and direct fibres, which at the anterior part of the chiasm can be separately distinguished, but at the posterior part and in the tractus become inextricably mingled. The macular fibres anastomose with each other in the retina, and they have additional opportunity to do this in the chiasm and the tractus.

The tractus winds around the *crus cerebri* and terminates in two roots upon the *corpora geniculata externa* and *interna*, and upon the posterior part of the *optic thalamus*, called the *pulvinar*. Fibres also go to the anterior part of the *corpora quadrigemina*, but these organs are not regarded as concerned in vision, but in the activity of the pupil. The parts just referred to are called the *primary visual ganglia*, or *primary optic centres.*

In them are found innumerable ganglion cells in which the fibres of the tractus lose themselves, and thereafter a new set of fibres proceeds backward through the posterior part of the *internal capsule* to the cortex, under the name of the *visual radiation*, or *fibres of Gratiolet or of Wernicke.* Passing through the internal capsule they cross the sensitive fibres coming down from the hemisphere, are rather closely massed, and then, spreading out like a fan, rise upward, wind outside the tip of the *lateral ventricle* to reach their destination at the lower part of the median surface of the *occipital lobe.* (Fig. 137).

By comparing the description of the varieties of hemianopsia which follow, with the diagram on the opposite page, the student will understand the mechanism of their development.

The following from Seguin explains the lettering of the illustration :—

L. T. F., left temporal half field ; *R. N. F.*, right nasal half field ; *O. S.*, left eye ; *O. D.*, right eye ; *N.*, nasal and *T.*, temporal halves of

[1] This semi-decussation is denied by some observers.

the retinas; *N. O. S.*, left optic nerve; *N. O. D.*, right optic nerve; *F. C. S.*, left crossed fasciculus; *F. L. D.*, right lateral or non-crossed fasciculus; *C.*, chiasm or decussation of the fasciculi; *T. O. D.*, right optic tract; *T. O. S.*, left optic tract; *C. G. L.*, corpus geniculatum

Fig. 137.

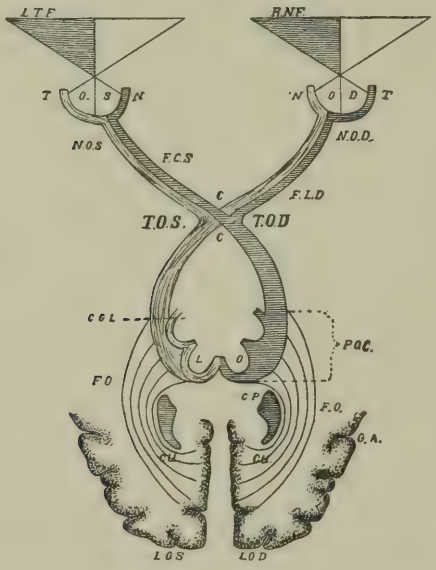


Diagram illustrating the visual path and its relation to the visual field, left lateral hemianopsia being shown (Seguin).

laterale (medial corpus geniculatum and its arms are omitted); *L. O.*, optic lobes (corpora quadrigemina); *P. O. C.*, primary optic centres (including corpora quadrigemina, corpora geniculata, and pulvinar of the optic thalamus); *F. O.*, optic fasciculus, radiating visual fibres of Gratiolet in the internal capsule; *C. P.*, posterior horn of the lateral ventricle; *G. A.*, region of the gyrus angularis; *L. O. S.*, left occipital lobe; *L. O. D.*, right occipital lobe; *Cu.*, cuneus and subjacent gyri constituting the cortical visual centre in man. The shaded lines represent the parts connected with the right halves of the retinas.

Varieties of Hemianopsia.—Hemianopsia is divided into *horizontal*, in which the dividing line between the darkened and preserved field is horizontal; and *vertical*, in which the dividing line is vertical.

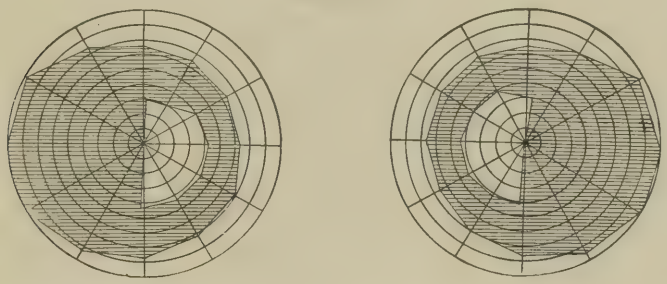
(1) *Horizontal Hemianopsia* (altitudinal) may be inferior or superior, both lower or both upper half fields being wanting.

In addition to diseases of the eye, it is possible that such a condition could arise under the influence of a lesion so situated as to press upon the upper or lower part of the chiasm, or downward upon one optic tract, or upon the lower or upper part of both optic nerves. A double lesion in front of the chiasm may produce loss of the upper half of the field in one eye and of the lower half of the field in the other eye.

(2) *Vertical Hemianopsia.*—This is subdivided into several varieties :—

(a) *Bitemporal Hemianopsia* (peripheral), in which both temporal fields are wanting.

Fig. 138.



L. R.

Bitemporal hemianopsia. The shaded areas represent the portions of the fields which are dark, and it is evident that there is entire loss of both temporal fields and some contraction of the preserved fields. From a case with lesion of the chiasm.

(b) *Binasal hemianopsia*, in which both nasal fields are wanting, is extremely rare ; it necessitates a lesion on both sides of the chiasm, or one on the outer side of each optic nerve, which disables the direct fibres.

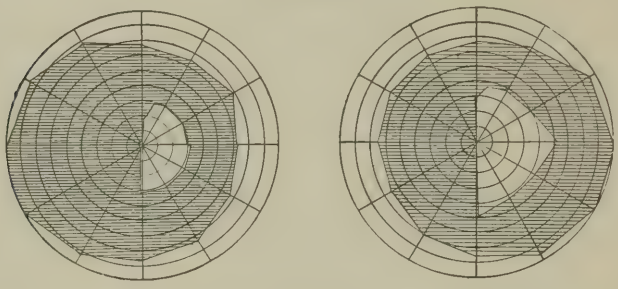
(c) *Homonymous Hemianopsia* (central), in which the corresponding half of the field in each eye is wanting : thus, both right or both left fields are darkened, in the former case indicating loss of function of the left half of each retina and designated *right homonymous lateral hemianopsia*, and in the latter case indicating loss of function of the right half of each retina, and designated *left homonymous lateral hemianopsia.* (Fig. 139.)

This is the commonest form of hemianopsia.

Hemianopsia may be *complete*, *i. e.*, the entire half of each field is

wanting, or *incomplete*, *i. e.*, a portion of each half field is wanting, the defect usually being in the form of a quadrant. (Fig. 140.)

Fig. 139.

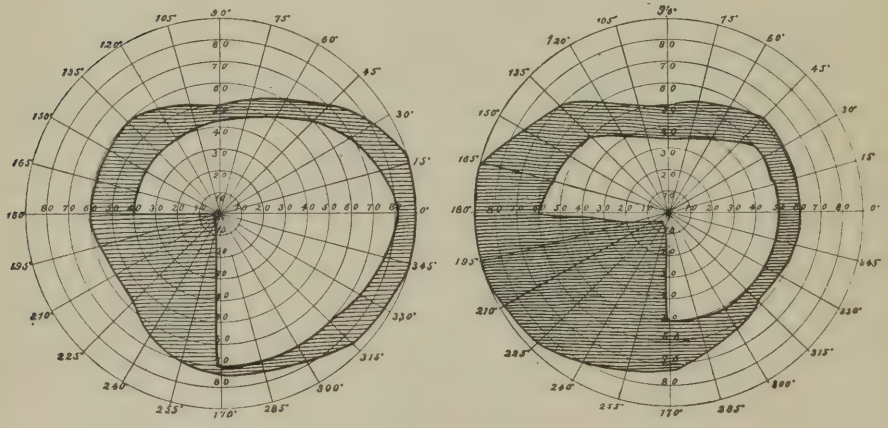


L. R.

Left homonymous lateral hemianopsia. The shaded areas represent the portions of the field in which vision was lost, and it is evident that both left fields are wanting, the temporal retina of the right eye, and the nasal retina of the left eye having lost function. The remaining fields are contracted. The lesion was a hemorrhage involving the optic radiations of the right side.

The preserved half fields may be of their normal size, or they may exhibit concentric contraction.

Fig. 140.



L. R.

Quadrant homonymous hemianopsia, shading as before. The left lower quadrant of each field is wanting. The lesion is probably in the cuneus.

Finally, the hemianopsia may be *absolute*, *i. e.*, all the three functions of sight (perception of light, of form and of color) are

wanting, or it may be *relative*, *i. e.*, perception of color, or perception of color and form, is wanting in the deficient area of the field, but the light-sense is preserved.

Those rare cases in which only the centre for color, situated in the cortex of the occipital lobe, is damaged, and in which consequently the half-defect is present for colors alone, are described under the name *homonymous hemiachromatopsia*. In a remarkable case of this kind which the author has seen with Dr. J. William White, at the onset the hemianopsia was absolute; later light-sense and form-sense returned. The obliteration of the color-sense remains, although in all other respects the patient has recovered.

Peculiarities of the Dividing Line.—The dividing line may exactly cut the fixing point, or it may pass around this point and leave it within the region of preserved vision. The want of uniformity between the seeing and the blind areas may be manifested by the failure of the dividing line to coincide with the vertical meridian for some distance, by its assuming an oblique or irregular direction, or by forming an open angle. These peculiarities have been explained by anastomoses of the fibres from each optic tract in the retinas as well as in the optic nerves and chiasm.

Recently, the publication of some cases of *double* homonymous hemianopsia, in which there was preserved a small central field in each eye, indicates that there is a region in cortical visual centres which supplies the macula lutea, and that this was not destroyed.

Significance of Hemianopsia.[1]

(1) Bitemporal hemianopsia is caused by a lesion—tumor, aneurism or fracture, involving the crossing fibres from both optic tracts in the middle of the chiasm.

A unilateral hemianopsia, if not caused by disease within the eye, could originate from injury to one optic nerve.

[1] The student who is interested in the subject, in addition to the papers already quoted, is referred to a paper by Swanzy (Transactions of the Ophthalmological Society of the United Kingdom, Vol. IX. 1889) and especially to the contributions of Seguin (Journal of Nervous and Mental Diseases, 1886 and 1887).

(2) Homonymous lateral hemianopsia is caused by a lesion situated in the occipital lobe, the optic radiations, the internal capsule, the primary optic centres or the optic tract, in other words by any lesion which breaks the continuity of the visual tract back of the optic chiasm. (Consult Seguin's diagram and description.)

The student should remember :—

(*a*) The lesion is on the opposite side of the dark fields.

(*b*) If the preserved fields are accompanied by concentric contraction, the smaller half field will be in the eye opposite to the lesion ; contraction of the preserved half field is most common with lesions of the cortex, but also may occur in lesions of the tractus.

(*c*) If the hemianopsia is relative, the lesion must be in the cortex ; elsewhere it produces absolute hemianopsia ; but cortical lesions are not excluded by absolute hemianopsia.

(*d*) A lesion confined to the cuneus, or to it and the gray matter immediately surrounding it, on the mesial surface of the occipital lobe, produces homonymous lateral hemianopsia without motor or sensory symptoms, at least without these as a direct consequence of the lesion, although they may appear as *indirect*, or as they are sometimes called *distant symptoms.*

(*e*) A lesion producing typical hemiplegia, aphasia, if the right side is paralyzed, little or no anæsthesia and lateral hemianopsia, is probably due to disease in the area supplied by the middle cerebral artery.

(*f*) A lesion causing hemiplegia, hemianæsthesia and lateral hemianopsia is probably situated in the posterior portion of the internal capsule.

(*g*) A lesion causing hemianæsthesia, ataxic movements of one-half of the body, no distinct hemiplegia and lateral hemianopsia could be situated in the posterior lateral part of the optic thalamus.

(*h*) A lesion causing the symptoms of disease of the base of the brain, associated at the same time with changes in the pupil, changes in the nerve-head and lateral hemianopsia, could be situated in one optic tract or in the primary optic centres on one side.[1]

(*i*) Incomplete hemianopsia, assuming usually a quadrant-shaped defect, may be present on account of a lesion confined to the lower half of the cuneus. It may also occur with less definite limitations in lesions of the subcortical substance of the occipital lobe and then may be associated with other symptoms as hemiplegia and hemianæsthesia. Finally, it may occur from a lesion of the tract, but then will be accompanied by other symptoms indicating basal disease.

[1] The preceding paragraphs have for the most part been condensed from the rules given by Dr. Seguin for the diagnosis of the seat of lesion in cases of hemianopsia.

(*j*) A hemianopsia in which there is preservation of the light-sense, but loss of either the color-sense or the form-sense, indicates that the lesion is in the cortex of the visual centre.

The Pupil in Hemianopsia.—One of the most important localizing symptoms is obtained by carefully observing the reaction of the pupil in cases of hemianopsia.

The examination should be made as follows: The patient being seated in a dark room with the source of light somewhat behind him, the eye under examination is illuminated by the weak light reflected from a plane mirror, as, for instance, the one used in the shadow-test. With the other hand the observer reflects a more intense beam of light by means of the concave mirror of the ophthalmoscope in various directions into the pupillary space, care being taken that the light falls obliquely and is not diffused over the entire retina.

If, in hemianopsia, the light thus thrown upon both the blind and the seeing side of the retina causes contraction of the pupil, although this contraction may be somewhat sluggish when the ray falls upon the blind side, the lesion is back of the primary optic centres.

If there is no contraction of the pupil when the ray of light falls upon the blind side of the retina, but there is contraction when it falls upon the seeing side, the lesion is in, or in front of, the primary optic centres.

In the former instance the lesion is so situated that there is no disturbance of the sensory-motor arc of the pupils; in the latter, the lesion interferes with this arc, and the pupillary change receives the name *hemiopic pupillary inaction*. It is often called *Wernicke's symptom*.

Hemianopsia cannot be diagnosticated with the ophthalmoscope, and pallor of the corresponding half of the optic nerve is a very doubtful sign.

The *prognosis* depends entirely upon the cause of the visual defect. Complete recovery from hemianopsia may take place, as, for instance, in syphilitic deposits. If the lesion is a tumor, non-resolvable by alteratives, or a hemorrhage or spot of softening, the disease of the nerve fibres is such that reparation cannot take place.

CHAPTER XIX.

MOVEMENTS OF THE EYEBALLS AND THEIR ANOMALIES.

ANATOMY.—The movements of the eye are controlled by the action of six muscles, four straight and two oblique, in general terms, situated *in the orbital* region. In order to understand the anomalies of the external ocular muscles, it will be necessary to review a few points in their anatomy and physiology.

(1) The *superior rectus* arises from the upper margin of the optic foramen and from the fibrous sheath of the optic nerve, its point of origin lying beneath that of the levator and the superior oblique ; it is inserted by a tendinous expansion in the sclerotic coat, 7 mm. from the margin of the cornea.

(2) The *inferior rectus* and the *internal rectus* arise from the optic foramen by a common tendon, which is attached to the entire circumference of the foramen, except its upper and outer part. They pass forward in their several positions and are inserted by a tendinous expansion into the sclerotic coat, the internal rectus $6\frac{1}{2}$ mm. from the margin of the cornea, and the inferior rectus 7 mm. from the same position.

(3) The *external rectus* arises by two heads, one being attached to the outer margin of the optic foramen, and the other in part to the common tendon of the inferior and internal recti, and in part to a process of bone on the lower margin of the sphenoidal fissure. The tendinous expansion of the muscle is inserted into the sclera, 8 mm. from the margin of the cornea.

(4.) The *superior oblique* (trochlear) is situated at the upper and inner side of the orbit, and arises above the inner margin of the optic foramen. It proceeds to the inner angle of the orbit, at which point its rounded tendon passes through a fibro-cartilaginous pulley, occupying a little fossa just within the supraorbital margin of the frontal bone, and is then reflected backward, out-

ward, and downward beneath the superior rectus, being inserted about 18 mm. from the edge of the cornea, or at a point midway between the cornea and the entrance of the optic nerve. The insertion of this muscle lies between the superior and external recti.

(5.) The *inferior oblique* is situated at the bottom of the orbit and arises from a depression in the orbital plate of the superior maxillary bone, external to the orifice of the nasal duct. Passing beneath the inferior rectus it is directed outward, backward, and upward, and reaches its insertion into the sclera by means of a thin tendon, about 19 mm. from the corneal margin, within the position of the external rectus, and nearer the optic nerve than the cornea.

Nerve Supply of the Muscles.—The internal, superior, and inferior recti muscles and the inferior oblique are supplied by the *third* nerve, which also sends a branch to the levator palpebræ.

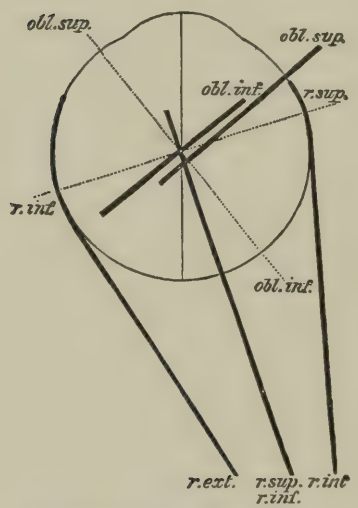
The *apparent* origin of this nerve is from the inner surface of the crus cerebri and immediately in front of the pons Varolii. The *deep* origin is traced to a nucleus on each side of the median line in the floor of the aqueduct of Sylvius beneath the corpora quadrigemina. This nerve pierces the dura mater below the posterior clinoid process, passes along the outer wall of the cavernous sinus, and divides into two branches which enter the orbit through the sphenoidal fissure between the two heads of the external rectus muscle. The superior division supplies the superior rectus and levator palpebræ. The inferior division separates into three branches: one goes to the internal rectus, a second to the inferior rectus, and the third and largest of the three to the inferior oblique. The last of these sends a branch to the ophthalmic ganglion forming its inferior, short, or motor root. The branches of distribution of the ganglion, or the short ciliary nerves, supply the ciliary muscle and the iris.

The *fourth*, *pathetic*, or *trochlear* nerve supplies the superior oblique muscle. It apparently arises on the outer side of the crus cerebri, just in front of the pons Varolii, and can be traced behind the corpora quadrigemina to the valve of Vieussens. Its deep origin can be followed to a nucleus in the floor of the aqueduct of

Sylvius below the origin of the third nerve. It pierces the dura mater near the posterior clinoid process, passes along the outer wall of the cavernous sinus, crosses the third nerve, and enters the orbit through the sphenoidal fissure, and is the highest of the nerves passing through the orbit.

The *sixth* or *abducens* nerve supplies the external rectus muscle. It apparently arises from the corpus pyramidale close to the pons. Its deep origin is from the floor of the fourth ventricle, from the gray substance of the fasciculus teres, and from a nucleus common to it and the facial nerve. The nerve pierces the dura mater on the basilar surface of the sphenoid bone, passes below the posterior clinoid process, enters the cavernous sinus, and finally reaches the orbit through the sphenoidal fissure, passes between the two heads of the external rectus, and is distributed to the muscle.

FIG. 141.



The axes of rotation (Fick and Foster).

PHYSIOLOGICAL ACTION OF THE MUSCLES.—The six muscles which move the eyeball may be considered as three pairs, each pair rotating the eye around a definite axis.

The superior rectus and the inferior rectus rotate the eye around a horizontal axis which forms an angle of 70° with the visual line; the superior oblique and inferior oblique around a horizontal axis which forms an angle of 35° with the visual line; and the internal rectus and external rectus around a vertical axis which is perpendicular to the visual line. These axes pass through the *centre of rotation of the eyeball* (about 14 millimeters behind the cornea).

A reference to the figure will explain the attachments, and the axes of rotation which have just been described. The vertical

axis of the muscles, being at right angles to the plane of the paper, is not shown in the diagram. (Fig. 141.)

The starting-point from which the actions of the muscles are reckoned is the *primary position* of the globe, defined by Mauthner as that position of the eyes from which the visual lines can be moved without the eyes being revolved around their axes. The eyes occupy about this position when they are directed straight forward, the head being held erect, and a distant object, situated in the median line of the visual plane, is observed with practically parallel visual lines. Positions of the eyes other than this are called *secondary positions.*

Lateral and vertical movements of the eyes are unaccompanied by *rotation* or *torsion movement* of the eyeball, or that movement which is a rotation of the eye around the line of fixation (a straight line which passes from the point of fixation through the centre of rotation and is practically identical with the visual line). Movements of the eyes into secondary positions are accompanied by torsion. (See next paragraph.)

Rotation of the Eyeball around the Visual Line.—The movements of the eyeball directly upward (combined action of superior rectus and inferior oblique), or downward (inferior rectus and superior oblique), or inward (internal rectus alone), or outward (external rectus alone), are around axes which are perpendicular to the visual line; consequently, if a vertical plane is passed through the visual line, its direction will not be deviated from the perpendicular in movements of the eyeball either directly upward, downward, inward, or outward.

In *oblique* movements of the eyeball, upward and inward (superior and internal rectus, with inferior oblique); downward and inward (inferior and external rectus, with superior oblique); upward and outward (superior and external rectus with inferior oblique); or downward and outward (inferior and external rectus with superior oblique), the eyeball is rotated around an axis which is situated obliquely to the visual line; the vertical plane of the eye is deviated in consequence to the right or left of the perpendicular.

The *vertical plane* is denoted by the term *vertical meridian*, and may be described as a line passing through the centre of either

pupil perpendicular to the line joining the centres of the two pupils in the primary position of the eyeballs; this line joins two opposite points of the corneal margin.

In any extreme movement in a diagonal direction this line will be observed to rotate like the spokes of a wheel (wheel-movement or torsion). The eyeball appears to rotate around the visual line; this is effected by the superior and inferior recti and the superior and inferior oblique muscles. The upper extremity of the vertical meridian of the cornea is deviated outward (toward the temple), by the inferior recti and inferior oblique muscles; and inward (toward the nose), by the superior recti and superior oblique muscles. The deviation of the vertical meridian is greatest when the axis of rotation coincides with the visual line.

From the previous description of the movements of the eyeball it will be seen that the superior and inferior recti exercise the greatest degree of torsion when the eyeball is drawn toward the nose, and either upward or downward.

The oblique muscles, on the contrary, exercise their maximum amount of torsion when the eyeball is drawn toward the temple, and either upward or downward. The inferior oblique, while it aids the superior rectus in upward movements, antagonizes it in the rotation of the vertical meridian, and the movement of the eyeball inward.

The visual line coincides most nearly with the axis of rotation of the superior and inferior recti, when the eyeball is drawn toward the nose; and most nearly with that of the superior and inferior oblique muscles, when the eyeball is turned toward the temple. The superior oblique aids the inferior rectus in drawing the eye downward, but antagonizes it in the rotation of the vertical meridian, and in the movement of the eyeball inward.

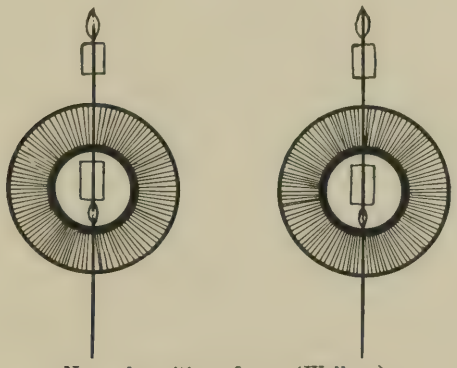
When the muscles are evenly balanced, the eyes in the extreme diagonal movements undergo a symmetrical deviation of the vertical meridians. The effect of this on the projection of the retinal images is free from disturbance, the obliquity being corrected by the judgment or by a counter movement of the head. (Fig. 142.)

In cases of paralysis of one or more of the eye muscles, this harmony no longer exists, and the resulting diplopia from unequal

movements of the eyes, bears with it obliquity of the double images toward each other.

This can be simplified for study by dividing it into two kinds: either the vertical meridians incline toward each other by their upper extremities; or else they diverge from each other.

Fig. 142.

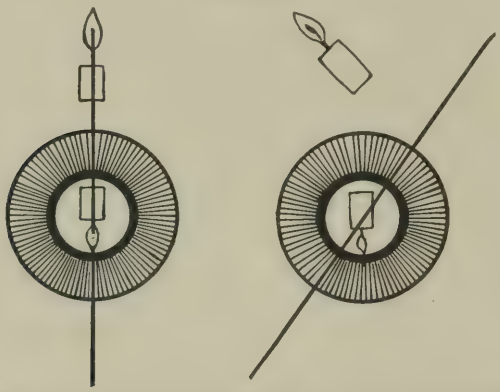


Normal position of eyes (Wallace).

The meridians *diverge* from each other when the upper extremity of one vertical meridian is directed toward the temple, while the vertical meridian of the other eye remains perpendicular. An object extending in a vertical direction, for example a candle, would form an inverted image on the retina of the eye whose vertical meridian is tilted toward the temple by its upper extremity, in which the flame of the candle would occupy the lowest portion of the image, lying somewhat on the temporal half of the retina, while the lower portion of the candle would occupy the highest portion of the image, somewhere on the nasal half of the retina. (Fig. 143.) In accordance with the law of projection, images on the nasal half of the retina are referred to the temporal portion of the field, and images on the temporal half of the retina are referred to the nasal portion of the field. With the vertical meridian tilted toward the temple, the candle forms an image on the retina which is projected outward, so that it seems to converge by its upper extremity toward that of the other eye when the diplopia is homonymous; when crossed diplopia exists, it seems to diverge.

The meridians *converge* towards each other when the upper extremity of one vertical meridian is tilted toward the nose, while the vertical meridian of the other eye remains perpendicular.

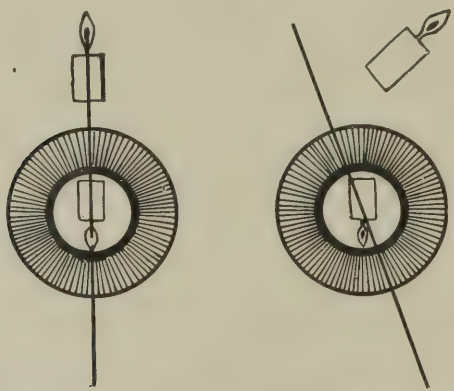
Fig. 143.



Vertical meridian of left eye diverging by its upper extremity.

When the vertical meridian is tilted toward the nose by its upper extremity, the image of the candle occupies, with its lower portion,

Fig. 144.



Vertical meridian of left eye converging by its upper extremity.

a point in the nasal half of the retina, and with its upper portion a point in the temporal half of the retina. It is projected outward in such a manner that it seems to lean away from that of the

other eye when the diplopia is homonymous; when crossed diplopia exists, it seems to lean toward that of the other eye. (Fig. 144.) The eye in which the vertical meridian tilts, or the eye in which the vertical meridian does not tilt, may be the defective one. The image of the paralytic eye is always the one which appears to be oblique. (Consult also pages 510 to 519.)

Associated Movements.—Except under pathological circumstances, there is co-ordination in the movements of the eyes, and the movement of one eyeball is associated with that of its fellow. If a distant object is to be looked at, and the right eye is turned to the right, the left eye is also turned to the right and to the same extent as its fellow, because of the associated action of the external rectus of the right eye and the internal rectus of the left eye under the same innervation-impulse. If one eye is elevated, the other is also elevated; if one is depressed, the other is also depressed. These are associated movements in the same direction.

If a near object is to be looked at, the visual axes converge for the point at which it is situated, because of the associated action of the internal recti of the two eyes (*convergence* or *accommodative* movement); if the eyes are removed from this point and directed to a distant object, the visual axes tend to parallelism, because of the action of both external recti.

If the associated movements of the eyes were not thus regulated by equal impulses from the co-ordinating centre, single vision would not be possible, because the images of any object would not fall upon *corresponding points* of the two retinas. Inasmuch as every normal individual has two normally constructed eyes, he must receive from every object two sets of sensations, which are blended into one, when the movements of the eyes are so arranged that the images fall upon corresponding retinal areas. If, for any reason, the movements of the eyes become disarranged so that the images do not fall upon corresponding or identical retinal areas, the images become double.

The desire for *binocular vision*, or single vision with the two eyes, which depends upon the blending of the two sets of sensations, or, as it is also called, *fusion*, is believed to be the origin of the impulse which directs the movements of the eyeballs,

especially in association in the same direction. The mechanism of images falling upon corresponding or identical parts of the retinas may be understood from the accompanying diagram:

Fig. 145.

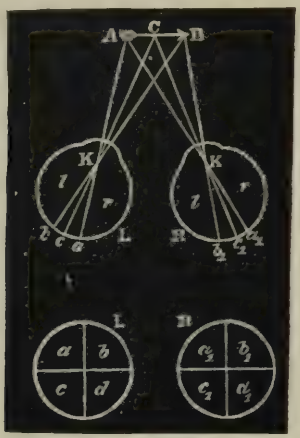


Diagram illustrating corresponding points. (Description and illustration from Foster.)

L is the left, and *R* the right eye, *K* the optical centre, a_1 b_1 c_1 corresponding to *a b c* in the left eye. *C c* $C c_1$ are the two visual axes, *c* c_1 the centres of the foveæ centrales of the two eyes. The object *A B C* is seen single, because the point *a* in the one retina "corresponds" to or is "identical" with the point a_1 in the other, and the point *b* in the one to the point b_1 in the other. The figures below *L* and *R* are projections of the left and right retina.

Thus, it is evident that a point situated anywhere upon the right side of one retina has its corresponding point upon the right side of the other retina, and points on the left side of one correspond with points on the left side of the other. The upper half of the retina of the right eye corresponds to the upper half of the retina of the left eye, and the lower half of the right to the lower half of the left; the nasal side of the right eye corresponds with the malar side of the left, and the malar of the right with the nasal of the left.

In addition to this desire for blending the two sets of sen-

sations into one, seen in the associated movements of the eyes in the same direction, there is also another regulating factor, *i. e.*, the connection between convergence and accommodation (see page 52).

Overcoming Prisms.—The power which the eyes have in producing fusion of the retinal images is represented by the value, in degrees, of the prism which they can overcome. As has been explained on page 76, this value for the external recti is equal to about 8°; for the internal recti about 50°; and for the vertical muscles about 3° to 4°. When a prism is placed before one eye with its base inward and diplopia is produced, an outward rotation of the eye occurs, and when the prism is placed with its base outward, an inward rotation of the eye takes place, and the influence of the prism is overcome, so that single vision again is possible within the limitations just stated.

Field of Fixation.—The eyes cannot be moved to the same extent in all directions, but are capable of the greatest movement downward and the least movement upward. The *field of fixation* comprises all the points to which the two eyes can be directed together, while the head is held in one position. The limitation of the excursion of the eyes, and consequently the possible shifting of the point of fixation, amount in the vertical and horizontal directions to about 90°, *i. e.*, the downward rotation equals about 60°; the upward rotation 30°; the inward 45°; and the outward 40°.

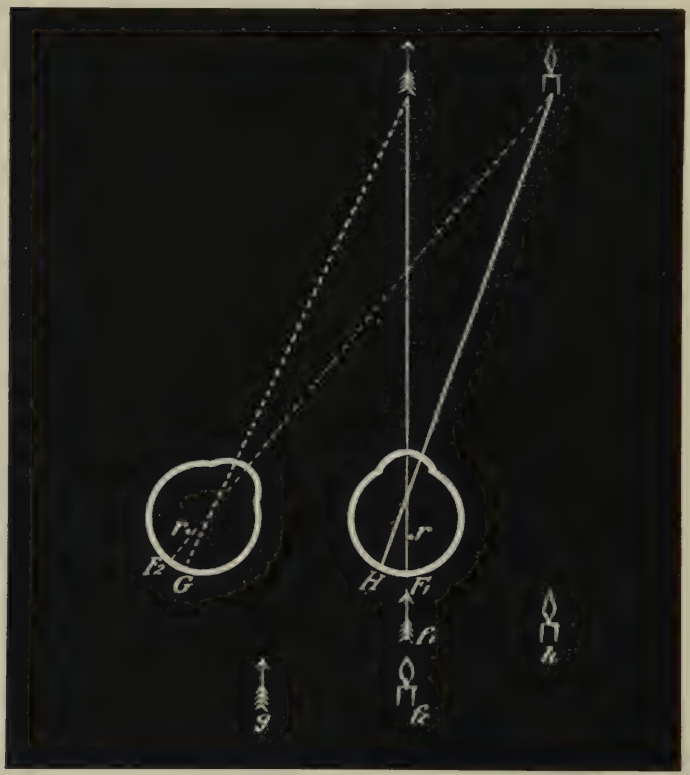
Strabismus or Squint.—Under the general term *strabismus* or *squint* are included those conditions which occur when the visual axis of one eye is deviated from the point of fixation. The eye whose visual axis is directed to the object fixed is termed the *fixing eye;* the other eye is termed the *squinting* or *deviating* eye. The deviation may be inward (*strabismus convergens*); outward (*strabismus divergens*); upward (*strabismus sursum vergens*); or downward (*strabismus deorsum vergens*).

1. *Convergent Squint.*—In this form of squint the visual line of one eye is directed to the object fixed. The visual line of the other eye is deviated inward, and intersects that of the sound eye at some point nearer than the object fixed. The image of

an object situated on the visual line of this eye would be formed on the fovea, and projected to the same point in the field of fixation.

Figure 146 represents a convergent squint of the left eye, and serves to explain the results of an inward deviation of one eye from any cause.

Fig. 146.



Convergent strabismus. Position and projection of the images. An object situated at the intersection of the visual lines would produce single vision (Wallace).

The centre of rotation is seen at r. The arrow is the object fixed; its image is formed on the fovea of the right eye F_1, and its position in the field is denoted by f_1. The candle forms its image on the retina of the right eye to the left of the fovea at H; its image is properly projected to the right, and its position in the field is denoted by h. The visual axis of the left eye is directed to the candle; its image is formed

on the fovea at F_2, and its position in the field is denoted by f_2, identical with that of f_1, because formed on an identical point of the retina. The arrow forms an image on the retina of the left eye at G, to the right of the fovea; it is consequently projected to the left of that of F_2, and its position in the field is denoted by g.

The right eye projects the images correctly; the left eye makes a false projection of the images to the left side, *i. e.*, to the side of the squinting eye. The diplopia is *simple* or *homonymous*.

2. *Divergent Squint.*—In this form of squint the visual line of one eye fixes the object, while the visual line of the other eye lacks the necessary movement inward to intersect that of its fellow at the point of fixation.

Fig. 147.



Divergent strabismus. Position and projection of the images. An object at the intersection of the lines H and G would produce single vision (Wallace).

As long as the visual axis of the affected eye intersects that of the sound eye in its anterior extremity, the affection may be

denominated *insufficiency of convergence.* When the visual axes no longer intersect anteriorly, but diverge from each other so that their posterior extremities intersect, the affection is properly denominated *divergent squint.*

Fig. 147 represents a divergent squint of the left eye, and serves to explain the effects of an outward deviation of one eye (from any cause) upon the position of the images of an object which is fixed.

The centre of rotation is at *r*. The arrow is the object fixed ; its image is formed on the fovea of the right eye at F_1, and its position in the field is denoted by f_1. The candle forms its image on the retina of the right eye to the right of the fovea at *H;* its image is properly projected to the left and its position in the field is denoted by *h*. The visual axis of the left eye is directed to the candle ; its image is formed on the fovea at F_2, and its position in the field denoted by f_2, identical with that of f_1 because formed on identical points of the retina. The arrow forms an image on the retina of the left eye at *G*, to the left of the fovea ; it is consequently projected to the right of that of F_2, and its position in the field is denoted by *g*.

The right eye projects the images properly ; the left eye makes a false projection toward the right side, *i. e.*, the side opposite to the squinting eye. The diplopia is *crossed* or *heteronymous.*

(3) *Upward and Downward Squint.*—If upward deviation of one eye (strabismus sursum vergens), or downward deviation of one eye (strabismus deorsum vergens), causes a diplopia, it is crossed ; the upper image corresponds with the lower eye and the lower image with the upper eye.

Paralysis of the External Ocular Muscles (*Paralytic Strabismus*).—This may be *complete* (the affected muscle is entirely paralyzed), or *incomplete* (the affected muscle is partially paralyzed or paretic).

A. General Symptoms.—Certain symptoms are common to paralysis of the external eye muscles.

(1) *Loss of Binocular Single Vision, or Diplopia.*—The cause of this, evident from the previous explanations, depends upon the deviation of the affected eye so that the images from an object are no longer fused, owing to their failure to fall upon "identical points" in the two retinas. Diplopia increases as the object is

moved to the side of the paralyzed muscle. In slight cases it amounts only to indistinct vision.

(2) *Non-Correspondence of the Direction of the two Eyes, or Strabismus.*—This depends upon the deviation to which the affected eye is subjected by the tone of the unresisted action of the muscle which is the antagonist of the paralyzed muscle, and also, in part, in old cases, upon the effect of secondary contractures. Squint is not always plainly manifest and may appear only if an attempt is made to move the eye in the direction of the action of the palsied muscle.

(3) *Loss, or Limitation of Movement* ("*Primary Deviation*").—The limitation of movement is always in the direction of the action of the affected muscle; consequently, the deviation of the eye is in a direction opposite to the action of the muscle.

(4) *Deviation of the Sound Eye, while the Affected Eye Fixes* ("*Secondary deviation*").—During the act of fixation by the affected eye, the same degree of nervous impulse passes from the centre to the muscles of the affected eye and to those of its non-affected associate; the former requires an abnormally great impulse to stimulate its movement, and hence the latter is over-excited, and the resulting movement is excessive. The secondary deviation, therefore, is greater than the primary deviation.

In order to demonstrate this the sound eye is covered with the hand, while the affected eye is directed toward an object held at a distance of about one foot. The covering hand is then moved from the sound to the affected eye. In order to fix the object, the sound eye must now move in a direction opposite to that toward which the paralyzed muscle rotates the ball. This backward movement represents the degree of previous excess called into existence by the undue amount of nerve-force which the normal muscle originally received. Thus primary and secondary deviations are in opposite directions, but both in the line of action of the affected muscle.

(5) *False Projection of the Field of Vision.*—This depends upon an inaccurate estimation of the position of an object situated in such a portion of the visual field that it requires an effort on the part of the affected muscle to turn the eye toward it. A normal

individual (his head being stationary, and one eye being closed, *e. g.*, the right) can readily and accurately touch an object lying within his reach to the left of the median line, because the degree of innervation required to make the lateral movement of the eye in order to see the object gives the necessary information, based on experience, how far to the left the object lies. Under the same circumstances an individual with a paretic left external rectus, instead of touching the object, would pass his hand beyond it, *i. e.*, to the left of it, because the excessive innervation which is now necessary to make the lateral turn gives the impression that the object lies farther to the left. In other words, the object is projected to a position in the visual field which it does not have.

(6) *Vertigo.*—This depends, both eyes being open, upon the diplopia and the confusion arising from trying to distinguish between the real and the false image. If one eye (the unaffected eye) is closed, it depends upon the condition described in the preceding paragraph. In order to explain the phenomenon under the latter circumstance, Mauthner has constructed the accompanying diagram and given this explanation :—

Fig. 148.

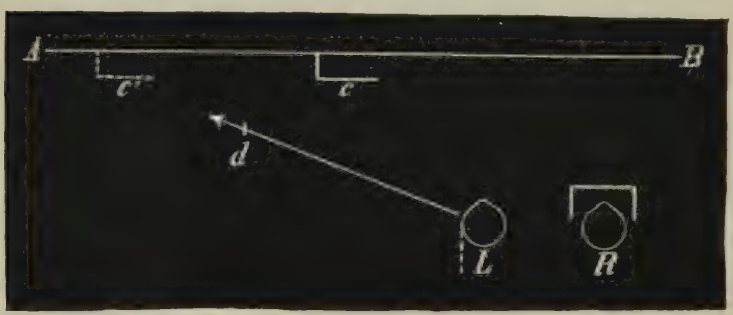


Diagram illustrating the phenomenon of ocular vertigo produced by false projection of the field of vision (Mauthner).

Suppose a person with paresis of the left external rectus, who turns his face to the wall *A B*, his right eye being covered, was directed to walk rapidly toward the door-latch *c*, lying to the left. Inasmuch as he projects this to *c'*, he walks rapidly in the direction indicated by the arrow. When he reaches *d*, he suddenly sees the door-

latch to his right, for, as soon as this is actually located to the right of the left eye, it will also be located correctly with the help of the healthy rectus internus of the left eye. At this moment a seeming motion of the door-latch from *C'* to *C* occurs, the room turns in a circle from left to right, and vertigo results.

In a paretic condition of the muscles which rotate the eye downward, vertigo may result from an erroneous localization of objects in the lower field, as they seem to lie in a plane deeper than they really are. For these reasons patients with ocular palsies commonly close the affected eye, although closure of either eye would remove the diplopia.

(5) *Altered Position of the Carriage of the Head.*—This depends upon the impulse of the patient to carry his head in that direction in which he is least troubled by the double images, and this is usually in the direction toward which the affected muscle moves the eye.

B. Varieties of Diplopia.—There are two varieties of diplopia, according to the relation which the double images bear to the eyes. If the right image pertains to the right eye, and the left image to the left eye, the diplopia is designated "*simple*" or "*homonymous;*" if the right image pertains to the left eye, and the left image to the right eye, the diplopia is named "*crossed*" or "*heteronymous.*"

The explanation of these conditions has been given (consult page 507 and Figs. 146 and 147). In order to aid the student's memory, Dr. Gowers has suggested the following rule: When the prolonged axes of the eyes would cross, the double vision is *not* crossed.

C. Special Symptoms.—The following paragraphs contain the most important symptoms peculiar to paralysis of individual muscles. For convenience it is supposed that the *right* eye is affected.

1. *External Rectus.*—The following phenomena may be present:—

(a) *Homonymous diplopia*, the images being side by side and parallel, if the eyes are directed on a horizontal level, the distance between them widening as the test-object is moved to the right.

If the test-object is moved to the right and above, and the eyes are directed toward it, the false image (image of the right or affected eye) diverges from the real image (image of the left or unaffected eye). This occurs because, under these circum-

FIG. 149.



A, position of images in paralysis of left external rectus, and *B*, in paralysis of right externus. The false image is bordered with a dotted line. (Fuchs.)

stances, the movement of the right eyeball toward the temple is limited by the feeble external rectus, and the eyeball fails to come into the position where the inferior oblique has its favorable condition for rotating the vertical meridian outward; hence the vertical meridian remains near to a perpendicular, while that of the sound eye is tilted toward it. There is divergence of the vertical meridians (the false image converges toward the real one) when the eyes are directed downward and toward the right, because the eyeball fails to come into a favorable position to have its vertical meridian tilted toward the nose by the superior oblique, while that of the other eye is tilted toward the temple by the inferior rectus.

(b) *Convergent strabismus*, which increases as the eye attempts to follow an object which is moved toward the right, during which it will be noticed that there is *limitation of movement* in this direction.

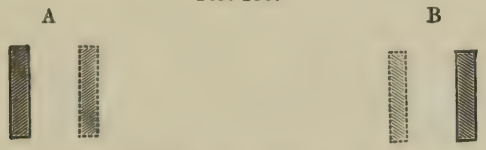
(c) The *secondary deviation* of the sound eye is inward; the *false projection of the field of vision* is to the right side, and the *face is turned* to the *right* (*i. e.*, to the side of the affected muscle).

(2) *Internal Rectus.*—There are present:—

(a) *Crossed diplopia*, the images being side by side and parallel, if the eyes are directed along a horizontal level, the distance between them widening as the test-object is moved to the left or if the eyes are directed upward. (Fig. 150).

If the test-object is moved to the left and above, and the eyes are directed toward it, the image of the affected eye is lower than that of the unaffected eye, and its upper extremity inclines toward it; if the test-object is moved to the left and downward,

FIG. 150.



A, position of images in paralysis of left internal rectus, and *B*, in paralysis of right internus. The false image is bordered with a dotted line. (Fuchs.)

the false image is higher and its lower extremity inclines away from that of the real image. These inclinations occur because, under these circumstances, the left eyeball is placed in a favorable position for one of the oblique muscles to rotate it, while the right eye is not brought in sufficiently for the superior or inferior rectus to exercise its torsion effect; consequently, the vertical meridians diverge on looking upward and converge on looking downward toward the left side.

(b) *Divergent strabismus*, which increases when the eye attempts to follow an object moved to the left, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is outward, the *false projection of the visual field* is to the left side, and the *face is turned* to the *left* (*i. e.*, to the side of the affected muscle).

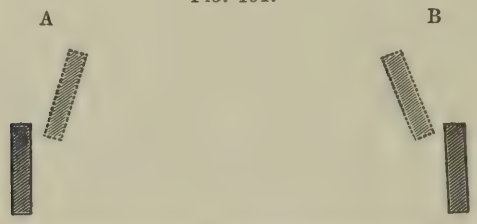
(3) *Superior Rectus.*—There are present:—

(a) *Crossed diplopia* in the upper field, the images being one above the other, the image of the affected eye being higher than its fellow and inclined to the left (healthy side), and the vertical distance between them (difference in height) widening as the test-object is moved upward and to the right. (Fig. 151.)

If the test-object is moved upward and to the left, and the eyes are directed toward it, the obliquity of the images increases, *i. e.*, the false image is still more inclined toward the sound side, away from that of the other. This occurs because, under these circumstances, the inferior oblique rotates the verti-

cal meridian of the sound eye to the left, while the affected eye, owing to the loss of power in the superior rectus, is unable to deviate its vertical meridian from the perpendicular; therefore the two meridians diverge, but the diplopia being crossed the images also diverge.

Fig. 151.



A, position of images in paralysis of left superior rectus, and *B*, in paralysis of right superior rectus. (Fuchs.)

(b) *Downward strabismus*, which increases when the eye attempts to follow an object moved upward, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is upward, the *false projection of the visual field* is too high, and the *face is directed upward.*

(4) *Inferior Oblique.*—There are present:—

(a) *Homonymous diplopia* in the upper field, the images being one above the other, the image of the affected eye being higher

Fig. 152.



A, position of images in paralysis of left inferior oblique, and *B*, in paralysis of right inferior oblique. (Fuchs.)

than its fellow and inclined to the right (*i. e.*, to the affected side), the vertical distance between them (difference in height) widening as the test-object is moved upward and to the left.

If the test-object is moved upward and to the right, and the eyes

are directed toward it, the obliquity of the images increases, *i. e.*, the false image is still more inclined away from the sound side. This occurs because, under these circumstances, the vertical meridian of the right eye is not tilted toward the temple owing to loss of power in the inferior oblique, while that of the left eye is tilted toward the nose by the superior rectus, now in its best position for tilting the vertical meridian inward; therefore the two meridians incline toward each other by their upper extremities.

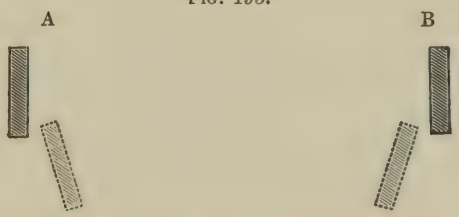
(b) The *direction of the affected eye* is downward and inward, which is more noticeable when the eye attempts to follow an object moved upward and outward, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is upward and inward, the *false projection of the visual field* is too far upward, and the *face is directed upward* and *toward the left.*

(5) *Inferior Rectus.* There are present:—

(a) *Crossed diplopia* in the lower field, the images being one above the other, the image of the affected eye being lower than its fellow and inclined to the right (*i. e.*, to the affected side), and the vertical distance between them (difference in height) widening as the test-object is moved downward and to the right.

FIG. 153.



A, position of images in paralysis of left inferior rectus, and *B*, in paralysis of right inferior rectus. (Fuchs.)

If the test-object is moved downward and to the left, and the eyes are directed toward it, the obliquity of the images increases, *i. e.*, the false image inclines still more toward the affected side. This occurs because, under these circumstances, the superior oblique of the left eye is in its best position for rotating the vertical meridian toward the nose; but the right eye, by reason

of its paralyzed inferior rectus, is unable to tilt its vertical meridian to correspond; therefore, the vertical meridian of the right eye remains perpendicular, while that of the left eye inclines toward it. The image of the right eye seems to be the oblique one; the images diverge, but the diplopia being crossed they seem to converge.

(b) *Upward strabismus*, which increases when the eye attempts to follow an object moved downward, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is downward and outward, the *false projection of the visual field* is too far downward, and the *face is directed downward* and to the *right*.

(6) *Superior Oblique.*—There are present:—

(a) *Homonymous diplopia* in the lower field, the images being one above the other, the image of the affected eye being lower than its fellow, and inclined to the left (*i. e.*, to the sound side), the vertical distance between them (difference in height) widening as the test-object is moved downward and to the left.

FIG. 154.



A, position of images in paralysis of left superior oblique, and *B*, paralysis of right superior oblique. (Fuchs.)

If the test-object is moved downward and to the right, and the eyes are directed toward it, the obliquity of the images increases, *i. e.*, the false image inclines still more toward the sound side. This occurs because, under these circumstances, the vertical meridian of the left eye is inclined toward the left by the inferior rectus, while that of the right eye is not rotated, owing to the feeble superior oblique; consequently, the meridians diverge.[1]

[1] In paralysis of the inferior rectus the diplopia is crossed; this feature distinguishes it from paralysis of the superior oblique. In both, the image of the affected eye sometimes seems to stand nearer to the patient than the other image.

(b) The *direction of the affected eye is upward and inward*, and is more noticeable when the eye attempts to follow an object moved downward and outward, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is downward and inward, the *false projection of the visual field* is too far downward, and the *face is inclined downward* and to the *left.*

(7) *Oculo-Motor Paralysis.*—There are present :—

(a) *Crossed diplopia*, the image of the affected eye being higher than its fellow, and its upper extremity inclined to the right (*i. e.*, to the affected side), the distance between them (*i. e.*, the lateral distance) widening as the test-object is moved to the left. If the test-object is moved upward, the difference in height and the inclination of the false image increase.

(b) *Divergent strabismus* and *limitation of movement* in all directions, except outward and slightly downward.

Fig. 155.



Double oculo-motor palsy (partial). From a patient in the Children's Hospital.

(c) The *secondary deviation* of the sound eye is outward, the *false projection of the field of vision* is to the inner side, and the *face is inclined* toward the *right*, the chin being tipped *upward.* In addition, there are ptosis, medium dilatation of the pupil which fails to contract to light, and paralysis of accommodation.

Method of Examination, and Diagnosis of the Affected Eye.—If the paralysis is complete, there is little difficulty in making a diagnosis by attention to the prominent symptoms which have been detailed. When the condition is one of partial paralysis (paresis), the important signs of strabismus and distinct limitation of movement being absent, the diagnosis must be based upon an investigation of the double images.

The patient is seated with the head and eyes in the primary position, five metres from the test-object (a candle flame), and one eye is covered with a piece of red glass (the ordinary trial cases are provided with a glass, suitably mounted, for this purpose). This distinguishes the flames and makes it easy to formulate the questions and follow the answers. Besides, patients are not always conscious of the false image, unless it is made to have a color different from that of the real one. The following points are then ascertained :—

(*a*) The relations of the double images to each other, and whether the images are visible in all portions of the field of fixation or limited to a certain portion of it; (*b*) the effect upon the lateral separation, the difference in height, and the obliquity of the images when the test-object is moved along the horizontal plane to the right or to the left, and above this plane, upward and outward and upward and inward, and below the plane, downward and outward and downward and inward; and (*c*) the character of the diplopia (crossed or homonymous).

Example: The red glass is before the right eye, the double images are parallel and on the same level, the red image being on the right side—hence the diplopia is homonymous. The images separate as the candle is moved to the right, while they come closer together and finally unite as it is moved to the left; hence the right externus is paretic, because the diplopia is homonymous, and the lateral distance between the images increases as the test-object is moved in the line of the action of the faulty muscle.

If the diplopia is crossed, under the same conditions, and the separation of the images is greatest as the candle is moved to the left, the left internus is affected. Paralysis of an abductor causes homonymous diplopia; of an adductor, crossed diplopia.

If the double images are visible only in the upper field, an elevator (superior rectus, or inferior oblique) is paretic; if only in

the lower field, a depressor (inferior rectus, or superior oblique). In the former condition the false image is higher; in the latter it is lower.

Based upon these facts, and upon the obliquity of the images, W. Czermak has formulated some helpful directions, and constructed the table which follows. The inclination of a false image always corresponds to the inclination which the paretic muscle in the sound state gives to the vertical meridian of this eye. All muscles which incline the upper end of the vertical meridian to the right are called *positive*, and all which incline it to the left, *negative rotators*. In paralysis of a positive rotator the false image is inclined to the right, in a negative rotator to the left, *i. e.*, this refers to the inclination of the upper end of the image from the position of the patient. The following table is given in *résumé* :—

Adductors (crossed diplopia).	Abductors (homonymous diplopia).
Internal recti.	External recti.
Superior recti.	Superior obliqui.
Inferior recti.	Inferior obliqui.
Elevators (false image stands highest.)	Depressors (false image is lowest).
Superior recti.	Inferior recti.
Inferior obliqui.	Superior obliqui.
Positive rotators (false image inclined to the right).	Negative rotators (false image inclined to the left).
Left superior rectus.	Right superior rectus.
Left superior oblique.	Right superior oblique.
Right inferior rectus.	Left inferior rectus.
Right inferior oblique.	Left inferior oblique.

The rotations of the vertical meridian may be summarized as follows :—

The meridians *converge* by their upper extremities in looking downward, and toward the sound side, in paralysis of the inferior rectus or internal rectus ; also in looking upward and toward the affected side, in paralysis of the external rectus, or inferior oblique.

The meridians *diverge* in looking downward and toward the affected side, in paralysis of the external rectus or superior oblique ; also in looking upward and toward the sound side, in paralysis of the superior rectus or external rectus.

Example.—The patient and the red glass are as before. The double images are one above the other and are visible only in the upper part of the field—hence an elevator is implicated. The red image is the higher, is slightly to the left of the other, and its upper end leans toward the left—hence there is crossed diplopia, and a negative rotator is at fault. This must be the right superior rectus, because the only muscle with which it could be confused is the inferior oblique, but paralysis of this produces homonymous diplopia, and on the right side this muscle is a positive rotator.

After the double images have been investigated in this way, the examiner proceeds to note the effect of prisms upon them, always remembering, in the case of the straight muscles, that the base of the prism should be placed over the insertion of the defective muscle; *e. g.*, in paresis of the right external rectus, a prism, with its base out, will gradually bring the images closer and closer, until finally one may be found through which the vision is single. In like manner the prism which would fuse the double images produced by a weakened condition of the superior, inferior, and internal rectus may be found.

In the case of the oblique muscles it may be necessary to use two prisms before it is possible to obtain single vision; *e. g.*, in the superior oblique, one with its base down to correct the difference in the height of the two images, and another with its base out before the unaffected eye, to neutralize the lateral separation.

When two or more muscles are paralyzed, for instance in partial oculo-motor palsy, it is exceedingly difficult at times to determine the exact condition of affairs. Sometimes help may be obtained by eliminating the influence of one weak muscle with a prism, and then dealing practically with the effect of a single paretic muscle. Thus, the left internal rectus may be paretic and also the left inferior rectus. That prism is found which, placed base inwards, brings the two images one above the other in an exact vertical line. This has eliminated the lateral deviation. The prism with its base down which fuses the two images is equivalent to the difference in the height which the paretic condition of the inferior rectus has produced.

Causes.—The lesion which causes paralysis of an ocular muscle has either a *central* or a *peripheral* situation, *i. e.*, it affects the

supplying nerve at its nuclei of origin, or at the base of the brain, or in the orbit. The following causes have been recorded:—

(a) *Syphilis.*—This is the most frequent cause, constituting about one-half of the cases (according to Alexander, 59.4 per cent.). The resulting paralysis may be peripheral (the most usual condition), owing to an inflammation or gummatous change affecting the nerve at the base of the brain, or in the orbit; or it may be central, owing to disease of the nuclei of the nerve, or of the brain in their immediate vicinity, or due to lesions in the third ventricle, the aqueduct of Sylvius, or the fourth ventricle (Alexander).

Syphilitic paralysis is generally one of the later manifestations. The oculo-motor nerve is most frequently affected. In rare instances, paralysis of the ocular muscles results from inherited syphilis (Graefe, Nettleship, Lawford).

(b) *Rheumatism.*—The paralysis is probably always peripheral, and the external rectus is most usually affected. It occurs after exposure (so-called "catching cold") in rheumatic subjects, but rarely, or not at all, during attacks of acute articular rheumatism.

(c) *Diphtheria.*—Usually the ciliary muscle is affected; occasionally, about a month after the onset of the disease, palsy of the external muscles has been noted. It may be bilateral.

(d) *Diabetes.*—A number of cases of palsy of the external rectus have been observed.

(e) *Poisons.*—Among the various poisons which have caused orbital muscle paralysis, the following are mentioned by Mauthner: Chronic nicotine poisoning; acute and chronic alcoholism; chronic lead poisoning; fish poisoning; and poisoning by gelsemium, chloral, and carbonic acid.

(f) *Diseases at the Base of the Brain.*—A meningitis (usually tubercular), a tumor, or an aneurism may press upon the cranial nerves as they pass along the base of the brain.

(g) *Diseases of the Spinal Cord, especially Locomotor Ataxia.*—Often the paralysis is temporary and partial. It may be associated with the pupillary changes characteristic of this affection. Relapses are frequent.

(h) *Injuries.*—The muscle may be directly paralyzed by being torn from its insertion, or there may be indirect paralysis owing

to periostitis of the orbit, fracture of the orbital walls, or even of the base of the skull.

(i) *Congenital Paralysis.*—A number of cases of congenital palsy have been observed, which in some instances may have been due to a lesion affecting the nucleus of the implicated nerve during intrauterine life. In addition to this, there are anomalies of the external eye muscles depending upon their abnormal insertion and even upon their entire absence.

(j) Finally, cases of orbital muscle palsy have been attributed to various so-called reflex disturbances. One type, affecting the oculo-motor, is intermitting in character. This has also been attributed to basal disease.

It is often difficult to ascertain whether the paralysis is *central* or *peripheral* in its origin. The differential diagnosis must be made by examining into the completeness of the paralysis and the existence of complications or associated symptoms. Peripheral palsies are more apt to be isolated and complete; those of central origin are often associated with other symptoms indicative of intracranial mischief. Some information is obtainable by noting the effect of prisms upon the double images. Graefe pointed out that it is almost impossible to fuse the images when the palsy which originated them is of central origin.

Relative Frequency of Paralysis of the Orbital Muscles.—Paralysis of the abducens (external rectus) is met with most frequently, the next in order of frequency being unilateral paralysis of the oculo-motor. After these comes paralysis of the superior oblique, inferior rectus, superior rectus, internal rectus, and inferior oblique. However, statisticians differ exceedingly on these points.

Prognosis.—The prognosis depends entirely upon the cause of the palsy. Some examples of peripheral paralysis, especially those depending upon syphilis and rheumatism, are readily amenable to treatment; in others, not only is the paralysis incurable, but the lesion which creates it may be a fatal one. Hence the importance of trying to decide between peripheral and central palsies and the character of the disease or lesion which produces them.

Treatment.—In syphilis the usual remedies are applicable, and in many instances the best results follow very large doses

of iodide of potash. Massive doses are often tolerated, and even if the paralysis has existed for a long time, cure may result. In rheumatism, in addition to iodide of potash, salicylic acid is useful, especially in the earlier stages. It may be given, not in combination, but at the same time as the iodide. The various causes which have been mentioned furnish the indications for other treatment. In suitable cases strychnia seems to do good, or ascending doses of tincture of nux vomica.

The great annoyance which is produced by the double images, may be remedied by covering the affected eye with a piece of ground glass. It may be conveniently mounted in a spectacle frame with a lens which corrects any ametropia upon the opposite side, provided it is a case suitable for such correction.

In some instances prisms may be worn which fuse the double images. This, of course, is possible only when the degree of strabismus is not too great, and the rules which are given for insufficiencies of the ocular muscles are in force (page 543). The base of the prism should be placed in the direction of the image which it is desired to influence.

Mechanical treatment has been suggested by Michel, and has been very extensively tried in this country by Bull. The conjunctiva is seized near the insertion of the affected muscle with forceps, and the eyeball is drawn forcibly, as far as possible, beyond the ordinary limit of contraction, and then back again. The eye is first cocainized. The movements are made daily, and continued for about a minute at a time.

Electricity may be tried, the great difficulty being in passing the current through the muscle. Ordinarily one pole, the cathode, is placed upon the closed lid, while the other is put upon the temple. Usually a current of more than 3 milliampères is unbearable. This is especially true if the pole is placed directly upon the sclera, the eye first having been cocainized. Very disagreeable flashes of light will usually take place if a current of more than 1 or $1\frac{1}{2}$ milliampères is employed. If faradism is tried, a very weak current should be selected.

Finally, after all other means have failed, tenotomy has been resorted to, or else advancement of the paralyzed muscle. In

many cases advancement of the paralyzed muscle and tenotomy of the antagonist are necessary. The best results are obtained in the lateral muscles. In case an injured muscle, that is one torn from its insertion, should be seen directly after the accident, it would be proper to find the ends of the divided muscle and stitch them together.

Ophthalmoplegia.—This term is used to designate paralysis of the ocular muscles, and is divided by systematic writers into *acute* and *chronic* ophthalmoplegia.

Hutchinson proposed to give the name "external ophthalmoplegia" to a class of cases characterized by symmetrical, progressive paralysis of the external muscles, in contrast to a group distinguished by paralysis of the intraocular muscles (iris and ciliary muscle), to which he applied the term "internal ophthalmoplegia." This distinction, however, is not now maintained, because the two sets of muscles may be affected in the same case. Neither does the symmetrical character of the palsy always exist.

Nuclear ocular paralysis is the name applied to palsy of the ocular muscles (external and internal) when the nuclei of the third, fourth, and sixth nerves are affected by a lesion which may be degenerative, inflammatory, or hemorrhagic. Ophthalmoplegia may arise in this way, and microscopic investigation has shown that chronic progressive paralysis of the eye muscles (chronic ophthalmoplegia) may result from nuclear disease associated with involvement of the nerves as far as their endings in the muscles; from degeneration of the muscles and nerve trunk (including its intramedullary course) with unaffected nuclei; and from interruption of the conduction of the intramedullary fibres by sclerotic foci, with unaffected muscle, nerve trunk, and nucleus (E. Siemerling). The majority of the cases of chronic ophthalmoplegia occur from nuclear disease.

Acute ophthalmoplegia, characterized by a rapid paralysis of all ocular muscles, may occur with hemorrhage (*e. g.*, apoplexy); with cases of poisoning (*e. g.*, alcohol, sulphuric acid, referred to on page 523); and perhaps with injury. Usually the cases have been fatal.

Chronic ophthalmoplegia is characterized by a loss of power in one or more eye muscles, which gradually increases and involves other muscles, until, it may be, every muscle is paralyzed. As before stated, however, this disease is not always symmetrical (it may be unilateral), nor are all the muscles always paralyzed. Double vision is present early, but later disappears. The levators do not usually lose their entire power, and, indeed, ptosis may be absent. The disease is essentially chronic and may last for years.

If the intraocular muscles escape (which is not always the case), there is strong presumptive evidence that the origin of the trouble is nuclear, but, according to Mauthner, it is not a characteristic sign. Siemerling concludes that nuclear disease may be inferred from external ophthalmoplegia, if it is not maintained that nuclear palsy must manifest itself as an external ophthalmoplegia.

Chronic ophthalmoplegia may be congenital, and has been reported as a hereditary affection. It occurs with constitutional syphilis, and has followed injuries. It is often associated with other affections of the nervous system, especially locomotor ataxia and progressive paralysis of the insane. It is more common in males than in females, and is a more serious affection in children than in adults.

Treatment.—In many instances this is wholly without result. If syphilis is present, the usual remedies are applicable, especially iodide of potash in massive doses.

Associated Ocular Paralyses.—Sometimes the eyes cannot make certain movements in which they are usually associated, although the directing power of the muscles may be unimpaired when they exercise their function in a different association. In other words, there is paralysis of movement and not of the muscles supplied by a given nerve. Thus the internal recti may be unable to draw the eyes together in the act of convergence, although they may act normally in helping to move the eyes from side to side; or there may be loss of the lateral movement (*e. g.*, right externus and left internus), although convergence is normal; or the vertical movement may be lost in each eye. Lesions affecting the centres for combined movements may pro-

duce such phenomena; symmetrical disease of the nuclei of the affected nerve explains some cases in which the upward and downward movement are lost.

In apoplexy, if the head is drawn from the paralyzed side, and the eyes are also turned to the sound side, the condition is called "*conjugated deviation of the head and eyes.*" Exceptions to this occur, and the head may be toward the paralyzed side. The rule is, according to Prevost, that in lesions of the hemisphere the head is drawn toward the lesion and away from the paralyzed side, but in lesions of the mesencephalon it is drawn away from the lesion and toward the paralyzed side. Should there be unilateral convulsions, with the eyes turned toward the convulsed side, there is an irritative lesion in the hemisphere, but if the head and eyes are turned away from the convulsed side, there is an irritative lesion in the mesencephalon (Landouzy).

Paralysis of the Internal Ocular Muscles.—Under the general term *cycloplegia* are included the cases of paralysis of the ciliary muscle. These may or may not be accompanied with dilatation of the pupil.

If the ciliary muscle is paralyzed, the chief symptom is loss of accommodation, precisely as it occurs after the instillation of a mydriatic. The loss of accommodation may be *complete*, or it may be *partial;* that is, one or more dioptres of the entire amount which is normal at the patient's time of life may still remain. After the fiftieth year it is difficult to detect cycloplegia.

It occurs from a lesion to the trunk of the oculo-motor nerve or in the anterior part of its nucleus. (Consult also oculo-motor palsy and ophthalmoplegia.) Unilateral cycloplegia is said to be possible under the influence of disease of the ciliary ganglion. A very common cause of double paralysis of the ciliary muscle is diphtheria. It also is associated with spinal disease.

Under the general term *iridoplegia* are included the conditions which occur when there is loss either of the direct or of the associated action of the iris. The chief symptom is connected with changes in the action of the pupil. The condition may or may not be accompanied with paralysis of the ciliary muscle. The various pupillary changes have been discussed in Chapter II., page 64. Consult also page 310.

Concomitant Squint.—This form of strabismus is characterized by the power of the squinting eye to follow the movements of the other eye in all directions.

Varieties of Concomitant Squint.—The four chief deviating tendencies of squinting eyes have been given (inward, outward, upward and downward). Concomitant squint may be *periodic* or *permanent;* the latter variety is either *monolateral* or *alternating.*

The average age for squint to begin is 3.4 years. Squints occurring later in life (after 5 years) are often alternating, in which case excellent vision exists in each eye.

Causes of Concomitant Squint.—The following causes may produce concomitant squint:—

1. Disturbance of the relation between accommodation and convergence by errors of refraction.
2. Disparity in the length or thickness of opposing muscles.
3. The size and shape of the eyeball and orbit.
4. The influence of the angle gamma.
5. Amblyopia of one eye by the loss of the natural stimulus of diplopia to exact convergence.
6. The distance between the pupils.

1. *Disturbances in the Relations of the Functions of Accommodation and Convergence.*—The relation between these two functions has been previously described (page 52). Some latitude of movement is possessed by each function separately; but a limit to the independent exercise of either function exists, beyond which neither function can operate alone. Thus, a hypermetropia of 6 D would require an accommodation of 6 D to neutralize it, the visual lines being parallel. This is rarely possible; some metre-angles of convergence will usually accompany the accommodative effort. The point of convergence is then nearer than the point accommodated for, constituting a convergent squint. Hypermetropia is, therefore, frequently accompanied by convergent squint.

In contrast to this, a myope of 10 D requires 10 metre-angles of convergence to see at his far point of vision, that is, the point at which he can see with relaxed accommodation. This is not usually possible, because the enormous convergence necessary to see at this point is too severe a strain; consequently, the visual

lines intersect at a greater distance than the point for which they are accommodated, and binocular vision is abandoned. The eyes, left to the preponderating forces, assume the direction seen during sleep and deep anæsthesia, viz., divergence. Myopia is therefore frequently accompanied by divergent squint.

Sometimes individuals possess unusual power in developing one or other of these two functions. Thus, the hypermetrope may develop his accommodation sufficiently to equalize the disparity in the refraction and thus avoid squinting. The myope may also develop his convergence beyond the usual amount so as to prevent divergence. Hence all hypermetropes do not have convergent squint; neither do all myopes have divergent squint.

2. *Disparity in the Length or Thickness of Opposing Muscles.*—The eyeball is moved in the four cardinal directions by the four rectus muscles. The four rectus muscles are arranged in two pairs, and each muscle of a pair is antagonistic to the other. They are very similar to the reins on a horse; when one muscle contracts its opponent should relax, and the degree of traction in the muscles of each pair should be equal. The same equality should exist between the corresponding muscles of the two eyes. Thus, with relaxation of convergence, the visual lines should have a parallel direction.

A longer or thinner muscle in the corresponding members of each pair would result in a limitation of the movement of the ball in the direction of these muscles, and a tendency in the passive condition for the eyeballs to deviate in the direction of the opponents. The opponents under these circumstances are shorter, or thicker, or both. After the equilibrium has been disturbed, the eyeballs, yielding to the stronger muscles, deviate more and more in the direction of the stronger muscles, which become still stronger by their tonic contraction, while their antagonists become weaker by being elongated. The internal rectus muscles in convergent squint are often found broad and fleshy, while in divergent squint the external rectus muscles are hypertrophied in a similar manner.

3. *The Size and Shape of the Eyeball and Orbit.*—These may dispose towards the production of either convergent or divergent squint. As the eyeball at rest tends to assume a direction mid-

way between the opposing muscles, the optic axis evidently is directed to their point of attachment at the optic foramen. The optic axis would thus coincide with the axis of the orbit. A narrow, horizontal diameter of the face might thus predispose to convergent squint, or an unusually broad diameter to divergent squint. These conditions often coexist with hypermetropia and myopia.

In the first class a very short ball, flattened in its antero-posterior direction, by its greater facility of movement would render convergence easier. The contrary condition, namely, elongation of the antero-posterior axis, would render this movement more difficult.

4. *The Influence of the Angle Gamma.*—This may dispose to squint, where it has an unusual value, by the disturbance it produces between convergence and accommodation.

In *hypermetropia* this angle is positive. The visual axes should converge less than the optic axes by the amount of this angle. In *myopia* they should converge more than the optic axes by the amount of this angle.

The most important relation this angle has to squint is that the operator should never try to measure squint with his own eye, as he may overestimate a divergent or underestimate a convergent squint.

5. *Amblyopia of one Eye, on account of the Lack of the Natural Stimulus which Diplopia gives to Exact Convergence.*—Amblyopia of the squinting eye is present in a large proportion of the cases of concomitant convergent strabismus (30 per cent.—Schweigger; 72 per cent.—Nagel).

Two views in regard to the production of this amblyopia have been held: One, that it is due to lack of use on the part of the squinting eye (*amblyopia ex anopsia*, or, according to Hirschberg's terminology, *amblyopia ex ablepsia*), *i. e.*, that the squint causes the amblyopia; the other, that it is congenital, depending upon imperfect development of the visual centres, *i. e.*, the amblyopia causes the squint. On the whole, Schweigger's theory that the amblyopia in the squinting eye is congenital, and helps to cause the strabismus, is more satisfactory than the other view.

An amblyopia which removes the stimulus of diplopia to exact

convergence may also include cases in which the visual acuity is diminished by refractive differences in the two eyes, by opacities in the media of one eye (especially corneal opacities), by congenital cataract, and by complete blindness. The failure to recognize diplopia causes the visual axes to vary considerably either towards convergence or divergence, without appreciation of this on the part of the patient. If the eyes are hypermetropic, they are apt to converge; if myopic, to diverge. Numerous cases of squint exist without amblyopia. By covering one eye where amblyopia does not exist, a latent tendency to squint often becomes manifest by the wandering of the covered eye either inward or outward.

6. *The Distance between the Pupils.*—This is conducive to squint in the same way as variations in the size of the orbit.

Single Vision in Concomitant Squint.—Diplopia is rarely noticed in concomitant convergent strabismus, because the eye involuntarily suppresses the false image, or else has learned to disregard it. It is noticed in low degrees of the affection, and at times in the residual squint after tenotomy, provided the squinting eye is not amblyopic. A convergent squint of from 12° to 18° would bring the image of the object fixed by the sound eye on the blind spot of the squinting eye, and hence no diplopia would exist. The fact may explain the absence of diplopia in some cases of concomitant squint and also in a few instances of paralytic strabismus.[1]

Diplopia is more frequently met with in concomitant divergent squint, especially in the lower degrees. The nearer the image of the squinting eye approaches the macula, the more distinct it becomes. To make the patient conscious of the diplopia, a red glass is placed before one eye which colors the image red, and to some extent diminishes its brightness; hence it should be placed before the eye which has the sharpest vision. A prism with its base down over one eye also facilitates the recognition of the diplopia. When the squint is very high, it is sometimes necessary to correct the larger part of it with prisms before diplopia becomes manifest, and if one eye is amblyopic diplopia cannot be produced.

[1] This explanation is suggested by Dr. Wallace.

Comparison between Concomitant Squint and Paralysis of an Ocular Muscle.—Non-correspondence of the direction of the two eyes is a sign common to both of these forms of squint, and the distinguishing features have been given in the preceding pages. They are here gathered in the form of a differential table.

Concomitant Squint.	Paralysis of an Ocular Muscle.
(1.) The movements of the squinting eye can follow those of the other eye in all directions.	There is limitation of the movements of the affected (squinting) eye in the direction of the paralyzed muscle.
(2.) The angle of squint always maintains the same size (Mauthner).	The angle of squint increases if the eye is moved in the direction of the paralyzed muscle, but decreases if the movement is in the direction of its antagonist (Mauthner).
(3.) The secondary and primary deviations are equal.	The secondary deviation is greater than the primary deviation.
(4.) There is no characteristic carriage of the head.	There is usually faulty carriage of the head, which is turned toward the side on which the diplopia is least annoying.
(5.) Diplopia is uncommon.	Diplopia is the rule.
(6.) There is no false projection of the field of vision.	There is false projection of the field of vision.
(7.) In the permanent variety the squinting eye is often amblyopic.	The squinting eye may often have the better vision of the two.
(8.) Considerable degrees of refractive error are common (H in convergent and M in divergent squint).	There is no special relation between the refractive condition and the squint.

Measurement of Convergent Squint.—1. Squint may be measured approximately by the deviation inward of the pupil of one eye while the other eye fixes an object. The pupil being situated 10.5 mm. in advance of the centre of rotation, its deviation inward or outward, measured on a rule, represents the tangent of the angle of the squint. A deviation of 1 mm. represents a squint of 5°. For this purpose, an ordinary rule divided into millimeters may be employed, or a specially devised instrument curved to adapt itself to the curve of the eyeball and known as a *strabisometer*.

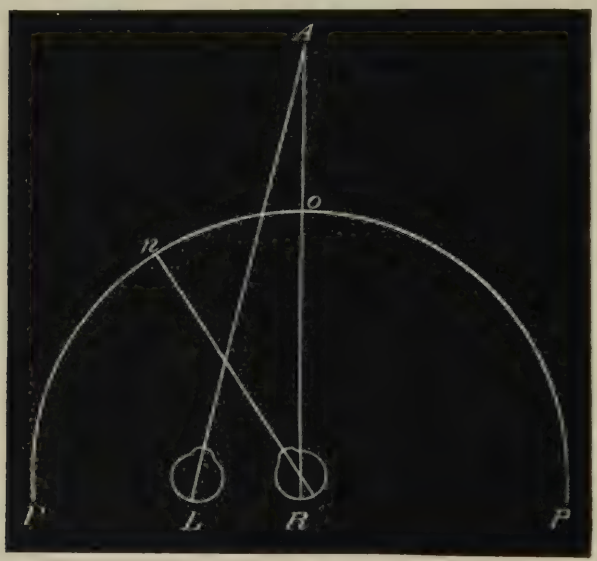
If diplopia is present, the extent of a squint may be determined

by what Swanzy calls the "Method by Tangents," and which he describes as follows :—

Upon a wall of the consulting-room, in a horizontal line, and so as to be on a level with the eyes of the patient, who is about 3 metres from the wall, are permanently marked out tangents of angles of 5° each, as seen from the place where the squinting eye is. Exactly opposite to the squinting eye is 0°, while towards the right and left the points are marked up to 45° or more. The flame of a candle being held at 0°, and one eye of the patient being covered with a red glass, he is called on to indicate the position of the image belonging to the squinting eye, and the number on the wall which corresponds to this gives the angle of the strabismus.

Under these circumstances the degree of prism necessary to fuse the double images may be used to measure the squint.

Fig. 156.



Measurement of Squint with a Perimeter.

2. *Angular Method.*—The perimeter may be employed to measure squint with great accuracy. Landolt thus describes the method :—

The deviating eye *R* is placed at the centre of the graduated arc of the perimeter *P P*, the arc lying on the plane of the deviation. The

patient is then required to fix with *his two eyes* a distant object, *A*, situated at the central radius *R o A*. This is the direction which the deviating eye should have in the normal condition. The point *n*, to which the eye in reality is directed, should now be determined; the angle *O R n*, formed by the deviating visual line *n*, with the normal line of fixation *A o R*, is the *angle of the strabismus*. In order to obtain this direction (*i. e.*, the point *n* at which the eye is directed), it would be necessary only to determine the visual axis. As this is not an easy matter, it is sufficient in practice to be contented with the optical axis; this differs from the former only by the angle gamma, which, in comparison with the large angle of the strabismus, may be neglected. The flame of a candle is moved along the arc of the perimeter until its reflection is in the centre of the pupil. This will occur when the flame is at *n*. The optical axis has now been found, and the size of the angle of strabismus may be read off.

Treatment of Concomitant Squint.—1. *Convergent concomitant squint.*

(a) *Spectacle Treatment.*—Glasses which completely neutralize the refractive error should be ordered for every case of convergent concomitant squint, after the prolonged use of atropine has thoroughly paralyzed the function of the ciliary muscle. In the majority of the cases refraction is hypermetropic, and is often associated with considerable degrees of astigmatism. Inasmuch as the squinting eye is frequently amblyopic, the ordinary method with trial lenses may not be satisfactory. Retinoscopy should then be employed, or the corneal astigmatism may be measured with the ophthalmometer. In young subjects, and especially in cases of periodic squint, glasses alone will many times suffice to cure the trouble; indeed, the squint sometimes disappears as soon as the physiological action of the atropine on the ciliary muscle is evident. In very young children good results may follow the prolonged use of weak solutions of atropine, even without the adjustment of neutralizing lenses. These, however, should be ordered as soon as it is safe for the child to wear spectacles.[1]

[1] Lang and Barrett, from an examination of 102 cases of convergent strabismus in which glasses had been used during periods of 6–24 months, conclude that the spectacle treatment produces a rapid and complete cure in about 10 per cent. of the cases; in 33 per cent. the cure continues so long as the spectacles are worn. The effect of the treatment is in direct ratio to the youth of the patient.

(b) *Orthoptic training* (*i. e.*, the establishment of diplopia and training the eyes to fuse the double images), in cases of squint was devised by Javal. It is suited to moderate degrees of strabismus and to instances of residual squint after operation. It requires considerable care properly to carry out the details. The treatment is not possible unless the patient sees double, or unless he can be trained to see double, *i. e.*, to appreciate the image formed in the squinting eye. This being the case, and the ametropia having been fully corrected, the exercises may be performed according to the method given by Landolt as follows:—

In an ordinary box-stereoscope, in the place of "views" two objects of some very simple shape are introduced; for instance, two vertical lines, one above and the other below the same horizontal line. These two lines, which may be brought toward, or removed farther from, each other at will, are placed at a distance about equal to that between the two eyes. Under such circumstances, their fusion into a single vertical line necessitates parallelism of the lines of fixation. This parallelism is generally possible only in the absence of any accommodative effect. Hence the sight-holes of the stereoscope are provided with + 6 D lenses (the length of the ordinary stereoscope being 16 cm.), which permit the subject to see at the distance of the objects without exercise of the accommodation.

The majority of patients do not succeed in fusing the images when their eyes are directed in a parallel direction. These latter generally show a certain convergence. The patient is then taught to find the distance between the two objects, which is requisite for the fusion of their images. When this is accomplished, the two objects are gradually separated more and more in successive sittings, until fusion is effected without the least convergence.

When binocular vision is obtained, with parallelism of the lines of fixation, which is equivalent to binocular vision at a distance, an attempt should be made to realize it for a point which requires a certain degree of convergence. To provoke a convergence of one metre-angle, the objects are brought together through a distance varying with the base line, the average being about one centimetre. In order to make the patient furnish an amount of accommodation equivalent to this amount of convergence, the strength of the convex lens is diminished one dioptre. The trials are continued in this way until the two objects are brought on a vertical line. At this moment they require, for their binocular fixation, a convergence of 6 metre-angles and an accommodation of 6 D. An emmetrope would, therefore, have to remove the glasses from the stereoscope, and see with the naked eye; an ametrope would require simply the correction of his refractive defect.

(c) *Operative treatment* consists of tenotomy of one or both internal recti, with or without advancement of the externus. The method of operating is described in the chapter on operations, page 617. An operation is inadvisable before the sixth year, and should never be undertaken until the refractive error has been fully corrected and the glasses have been worn for at least one month.

Preceding the operation the surgeon should estimate the degree of the squint, the presence or absence of diplopia, the visual acuity of each eye, and the power of the external recti.

It has been demonstrated that tenotomy of a single internal rectus corrects a deviation of about 15°, and, to use Landolt's expression, this serves "as a guide in the dosing of the effect and in the choice of the operation." It is proper to allow a residual squint of 3° to remain after the tenotomy, because the effect of the operation will slowly increase, and, if too much is done, divergence may be the ultimate result. If the strabismus is between 20 and 30°, after a single tenotomy, at least two months should be allowed to elapse, during which time the patient must constantly use his correcting lenses, before the second eye is submitted to a tenotomy. Some surgeons proceed at once to tenotomy of both internal recti in such cases, and others have advised increasing the effect of the division by passing a suture through the conjunctiva close to the corneal margin and drawing the eyeball outward toward the external commissure.

If the squint is more than 30°, and the squinting eye is amblyopic, it is usually necessary to combine tenotomy with advancement of the external rectus. In any case the effect of a simple tenotomy may be increased by incising the folds of the capsule of Tenon; but this should not be too readily done, as there is almost no means of gauging the effect. Moreover, it may lead to some disagreeable complications, which are referred to in the chapter on operations. On the other hand, if a tenotomy has been overdone, its effects may be diminished by inserting a suture, a practice which many surgeons perform under all circumstances.

(2) *Divergent Concomitant Squint.*—The treatment of this form of concomitant squint includes the correction of the error of refraction, with suitable glasses and operative measures.

(a) *Glasses* which neutralize the refractive error (most commonly myopia or myopic astigmatism) should be adjusted according to the rules which are given in the chapter devoted to the measurement of abnormal refraction.

(b) *Operative measures* depend entirely upon the degree of the deviation, the vision in the diverging eye, and the cause of the difficulty. When true divergent strabismus exists, it is usually necessary to perform an operation to correct it. This may be either tenotomy of one or of both externi, or this operation may be combined with advancement of the internal rectus.

If the sight has so much depreciated in the squinting eye that there is no possibility of binocular vision, the effect of the operation is a cosmetic one. If there is still the possibility of binocular vision, and there is a low degree of divergent strabismus, this operation must not be undertaken until the relative strength of the muscles has been carefully considered, lest excessive convergence and troublesome diplopia are produced. This will be referred to again in the section devoted to insufficiency of the internal recti.

Results of Tenotomy in Convergent Squint.—The effect of the operation, if well performed, is to produce parallel visual axes, and thus remove the disfigurement which is so annoying to the patient.

A very desirable effect, but one rarely obtained, is improvement in the vision of the squinting eye and securing binocular vision. There is much difference of opinion upon this subject, but it seems unlikely that there is ever very distinct permanent improvement in visual acuity.[1] So, too, binocular vision, even after the most perfectly performed tenotomy and after the patient has been carefully corrected with glasses and trained by orthoptic exercises, is not common. Noyes believes that less than 20 per cent. of successes in this particular field are obtainable.

In order to ascertain whether true binocular vision exists, the exercises with a stereoscope already quoted are efficient. A very simple experiment detailed by Mr. Swanzy is to hold a pencil

[1] There is no definite evidence to show that valuable improvement in the amblyopic eye ever takes place under any circumstances (Lang and Barrett).

midway between the eyes of the patient and a printed page, perpendicular to the lines of type. This presents no obstacle in reading if binocular vision is present, but in the event of its absence, portions of the page will be obscured by the pencil.

Dr. J. A. Lippincott, of Pittsburgh, has suggested that the binocular metamorphopsia produced by correcting lenses, and referred to on page 182, may be utilized for testing binocular vision, which is necessarily present if this phenomenon takes place. His method is as follows :—

A + 2 cylinder, vertical, is held before one eye, while a twelve-inch-square card is placed at the ordinary reading distance and the patient asked to describe which of the two sides is higher. As a control test the cylinder is now turned with its axis horizontal and the card again viewed. That side which in the first place appeared higher, now seems to be lower than the other.

Spastic Strabismus.—This occurs only under rare circumstances in hysteria and brain diseases (meningitis). It is difficult of diagnosis, periodical concomitant squint in hypermetropia being sometimes inaccurately described as due to spasm of the internal rectus (Mauthner).

Insufficiency of the Ocular Muscles.—This consists of a disturbance of the normal balance of the external eye muscles, which creates a tendency for the visual lines to depart from parallelism (heterophoria of Stevens's classification), a tendency which is checked by the habitual desire for binocular vision, or that vision in which the images of an object formed on the retinas of the two eyes make but a single mental impression.

Insufficiency differs from *squint* because in the latter the fusion of the images is usually impossible (*i. e.*, binocular vision is absent), and there is an evident departure of the visual lines from parallelism, which gives rise to the term which designates the condition.

Causes.—Insufficiency of the ocular muscles may be due to (*a*) errors of refraction, associated with prolonged use of the eyes under unfavorable circumstances ; (*b*) congenital weakness of the muscles ; (*c*) part of a general lack in muscular tone, depending either upon anæmia, nervous exhaustion, pelvic disorders, etc., or upon a more definite cause, *e. g.*, malaria, rheumatism, uric

acid diathesis, oxaluria; and (*d*) excessive action or spasm of opposing and dominating muscles (Noyes).

Referring to insufficiency of the power of convergence, Landolt distinguishes two forms: one which depends upon the absolute or relative weakness of the adductors or upon their insertion, and the other which has a central origin, and depends upon deficient power of fusion, or upon disturbances of innervation.

Relative Frequency of Insufficient Muscles.—Formerly it was customary, almost exclusively, to confine the term "insufficiency" to weakness of the internal recti. In recent times much attention had been paid to insufficiencies of the other muscles.

Faulty directing power of the vertical muscles is the least common of these anomalies, although its importance in causing asthenopic symptoms and disturbing the action of the lateral muscles, according to Stevens, is of paramount importance.

Probably the majority of observers would agree that insufficiency of the internal recti is the most common of the anomalies now under discussion, but Dr. Noyes considers that weakness of abduction (insufficiency of the externi) is a far more fruitful cause of muscular difficulties than weakness of adduction (insufficiency of the interni), the preponderance being not far from 3 to 1. The author's experience, based upon a large number of measurements, induces him to believe that insufficiency of the externi is a very common cause of trouble.

Heterophoria may be associated with any type of refractive error, and insufficiency of the interni, although common in myopia, also occurs frequently in hypermetropia and hypermetropic astigmatism.

Symptoms.—These are usually classified under the general term *muscular asthenopia*, and may be divided into the *ocular* and the *general* symptoms.

To the *first group* belong pain, often over the insertion of the insufficient muscle, and especially marked when the eye is suddenly moved in the direction of its action; blurred vision and imperfect power of working at close ranges; inability to gaze attentively at a stationary object or person even at long ranges, and great discomfort when attempting to watch moving objects;

dread of light, and blepharospasm, often confined to a few fibres of the orbicularis; and local congestions of the conjunctiva and margins of the lids. Often a patch of injected vessels will appear in the ocular conjunctiva over the insertion of the insufficient muscle (Lippincott).

In the *second group* a prominent symptom is headache, which may be situated in any portion of the cranium, but which is common in the occiput. Sometimes the pain immediately follows the use of the eye, sometimes it is delayed and sometimes it comes on at a certain hour of the day, or even night. According to Gruening, morning headache (*i. e.*, headache on waking) is usually due to nasal catarrh.[1]

Pain in the back, especially between the shoulder blades, is often described. Vertigo, generally subjective, is common, one variety being characterized by a sense of falling forward when walking in a crowd, associated with confusion of ideas. Drowsiness, and, on the other hand, insomnia may be present, and a variety of general, or so-called reflex neuroses.

Chorea, epilepsy, melancholia, migraine, palpitation of the heart, night terrors, symptoms resembling flatulent dyspepsia, and a host of other complaints have been attributed to muscular and also to accommodative asthenopia. There is no doubt that many instances of remarkable nervous disturbances, associated with insufficiencies of the ocular muscles (as well as with refractive error), have been observed, and that cure has followed the correction of the ocular difficulty, but there is also no doubt that the whole matter has not always escaped exaggeration.

Method of Examination.—The method of examining the ocular muscles has been fully described in Chapter II. Two points deserve reiteration, viz., that a measurement of the relative weakness and power of the muscles is inexact unless this has been made after the refractive error has been corrected, and the muscles have been tested through the correcting lenses; and that the examinations of the muscles should be made both for the

[1] The association between nasal disease and neurasthenic asthenopia is referred to on page 417.

near and the *far* point (*i. e.*, at 30 cm. and 6 metres), the latter being the more important determination.

TREATMENT.—An absolute balance of the external eye muscles (strict orthophoria) is quite as rare as emmetropia, and hence small errors of the lateral muscles are often unimportant.

If there is a general disorder, or an insufficient nervous tone, of which neurasthenic asthenopia may be an expression, this must be treated upon general principles. Strychnia or ascending doses of tincture of nux vomica are an efficient remedy. Galvanism may be tried, but it is doubtful if the current reaches the muscle.

In every case of insufficiency the refractive error should be corrected, according to the rules already laid down. This alone will often suffice to cure low degrees, and with their disappearance the associated symptoms subside.

If the asthenopic symptoms continue, recourse may be had to *gymnastic exercises with prisms*. The object is to strengthen adduction and abduction; hence the patient is instructed to practise fusing the double images produced by viewing a candle-flame situated six metres away. Thus, to exercise the interni, a prism of 10 degrees is placed base out before one eye, and as soon as the diplopia produced is overcome, 5 degrees (centrads) more are added, and so on until the limit of adductive power is reached. If the externi are to be exercised, the position of the prism is reversed, and the exercise begun with a prism of lower power—*e. g.*, 3 degrees. These exercises should be repeated every day, for ten or fifteen minutes at a time, until the patient has acquired the power to overcome readily 50° with the interni, and 8° with the externi. The exercise should now be continued with prisms of the power just named, but it is not necessary to attempt further increase. It is not always possible to reach this standard, and on the other hand many subjects can overcome much stronger prisms. This form of treatment is applicable especially to cases of weakness of the interni.

Another method, devised by Dr. Dyer, is to make the asthenopic patient, provided with abductive prisms, read, or perform some form of close-eye work, for a certain number of minutes every day, and to increase the amount by one or two minutes each day. The dosage is regulated with clock-like exactness. This exercise

should not be undertaken early in the day, and never with a poor light.

The next method of treatment is the *prescription of prisms* to be worn constantly or only during the act of reading, etc. The action of prisms has been explained (p. 21). Much difference of opinion exists in regard to their therapeutic value, and many surgeons are disinclined ever to employ prisms to aid *weak* abducting or adducting eye muscles, *i. e.*, those with deficient directing power, because they believe the defective muscle should be exercised and not favored, although they may order them when the range of movement is perfect, but in an unavailable position. There is one rule which admits of no exception in ordering prisms: The base of the prism should be placed toward the muscle which is to be aided and the apex toward the muscle which is to be weakened.

It is usually uncomfortable for the patient to wear more than 4 or 5 degrees constantly, *i. e.*, 2 or $2\frac{1}{2}$ over each eye. This statement admits of many modifications, and often the strength of the prism may be increased much beyond this limit.

In insufficiency of the vertical muscles (right or left hyperphoria) the defect is often quite small, and usually not above 4 or 5 degrees; hence prisms may readily be ordered and combined with the lenses which correct the refractive error, forming a prismosphere. If, for example, there is right hyperphoria of 2°, a 2° prism base down before the right eye corrects the difficulty, or, what is equivalent, the prism may be divided between the two eyes, *i. e.*, 1° base down before the right, and 1° base up before the left. It is safe to correct very trifling errors in the vertical muscles either with prisms or by decentreing the correcting lens to an equivalent degree (see table, page 186), provided these errors are still maintained after continuous use of glasses which neutralize the refractive error.

In insufficiency of the externi (esophoria), which is a frequent cause of muscular asthenopia (according to Noyes, the most frequent cause), low degrees of prisms may be combined with the correcting lenses and worn constantly with advantage. Dr. Noyes's rule is as follows: "If adduction stands at 20° or 25°, and after a few days rises still higher, while abduction

remains at 5°, and distressing symptoms exist, the indication for prisms with bases out is clear enough for trial. If abduction be $4\frac{1}{2}°$ or less (because half degrees are important), the indication is conclusive."

In insufficiency of the interni (exophoria) the constant use of prisms is not so valuable as in esophoria. On the other hand, they may be a great help in relieving the strain upon convergence by removing the point of intersection of the visual axes farther from the eyes, and for this purpose they are constantly combined with reading glasses. In high degrees of exophoria, or if there is actual divergence, abductive prisms are of little use; if the deficiency of the directing power is determined to be equivalent to 10°, one-half of this may be corrected (*i. e.*, $2\frac{1}{2}°$ base in over each eye); if it is desired to remove all effort, the faulty tendency is measured in the usual way, and, if it is within suitable limits, prisms are ordered, combined with the correcting glasses which neutralize the defect.[1]

In the event of failure to relieve asthenopic symptoms by the methods thus far described, operative procedure may be necessary. This consists of either partial, complete, or graduated tenotomy of the antagonistic muscle, or of advancement of the feeble muscle (see OPERATION chapter). Before a complete tenotomy is done the power of the opposing muscle should be carefully ascertained, and this should possess distinct preponderance. In case a tenotomy is to be performed to relieve esophoria, the interni should possess the full adductive power. If an externus is to be divided, there is great danger of producing annoying convergence, unless the patient is able to fuse the double images of a candle flame, placed 5 metres distant, produced by an abductive prism (prism with its base inward) of 10° or 12°. After the tenotomy, homonymous diplopia in the middle line not greater than the equivalent of a 10° prism is proper; but if the candle flame is moved 20° to the side opposite to the one on

[1] When a spherical lens is combined with a prism, the deviating effect of the combination is different from that of the prism alone. Mr. Archibald Percival (Ophthalmic Review, October, 1891) has constructed elaborate tables which give the deviating effect.

which the operation has been done, single vision should result. If it does not, the excessive effect must be overcome by a suture.

Graduated tenotomies or partial tenotomies are performed by many surgeons, and adjustments (especially of the vertical muscles) are exactly made. The former method is advocated by Dr. Stevens. Many brilliant results have been secured by experienced operators, but there seems little doubt that a good deal of injudicious "snipping of the tendons of the ocular muscles" has been practised.

Nystagmus.—This term is applied to a condition characterized by an involuntary, rapid movement of the eyeballs. The movement may be from side to side, or in a vertical or rotary direction.

The condition may be *congenital* or *acquired*, and is bilateral in the vast majority of cases, although a few instances of unilateral nystagmus have been reported, with the movements usually in the vertical direction. It is possible, however, inasmuch as slight forms of nystagmus are detected only by using the ophthalmoscope and watching the fundus, that some of these supposed unilateral cases have actually been bilateral.

The movement is nearly always in the lateral direction. According to Gowers, the extent varies from 1 to 10 mm., and the frequency from 60 to 200 separate oscillations per minute.

Congenital nystagmus is seen with cases of defective construction of the eyeball—coloboma, microphthalmos, etc. It is also common in albinism. Nystagmus also occurs with opacities of the cornea and degenerations within the media, especially when such obstruction to the rays of light has been caused by diseases occurring early in life.

Nystagmus may be acquired by the pursuance of certain occupations, especially mining, and is commonly known as *miner's nystagmus*. It generally occurs among those who use a dim light, and whose work necessitates keeping the eyes in an unusual position for many hours together (Snell).

Finally, nystagmus is exceedingly common in diseases of the nervous system, particularly disseminated sclerosis and Friedreich's ataxia. It occurs in many diseases of the brain, and has been noted with great frequency in tumors of the cerebellum.

Nystagmus has been ascribed to chronic fatigue of the muscles

and oscillation of the globe consequent upon the muscular atony, and also to a central origin. In some cases it is probable that both explanations are correct.

Treatment.—If practicable, in cases of nystagmus where there is interference with the reception of perfect retinal images, the best possible vision should be restored by correction of refractive error, by tenotomy or by iridectomy for new pupil, according to the indications. Very often good results have been noted. If nystagmus is brought about by any occupation, the evident indication is to remove the patient from his surroundings. For central nystagmus from brain or cord disease there is practically no remedy.

CHAPTER XX.

DISEASES OF THE LACHRYMAL APPARATUS.

Diseases of the lachrymal structures naturally divide themselves into those which have their seat in the lachrymal glands and those which affect the drainage system, *i. e.*, the puncta, canaliculi, lachrymal sac, and nasal duct.

Dacryoadenitis.—This is an inflammation of the lachrymal gland, a comparatively rare affection, which may be *acute* or *chronic*, *suppurative* or *non-suppurative*.

Non-suppurative dacryoadenitis, on account of its analogy to bilateral parotitis, has been called *mumps of the lachrymal gland* (Hirschberg). The monolateral chronic form of inflammation of the lachrymal gland is more common, and has been observed in scrofulous subjects, and may be caused by an injury or follow diseases of the conjunctiva and cornea.

If the gland is chronically enlarged, palpation will reveal its lobulated border; if the inflammation is acute, there are pain, tenderness, and swelling at the upper and outer part of the eyelid, with chemosis of the conjunctiva. This may go on to suppuration, and the abscess usually points upon the skin, but occasionally through the conjunctiva.

Treatment.—Warm applications and poultices to relieve pain are needed, and at the first appearance of pus an incision should be made either through the integument parallel to the eyebrow, or through the conjunctiva. If induration of the gland occurs, this is to be treated locally with iodine or iodide of cadmium ointment.

Hypertrophy of the Lachrymal Gland has been observed at birth, but usually is seen in later years, and consists in an indurated lobulated tumor having its situation in the upper and outer part of the orbit.

Spontaneous Prolapse of the Lachrymal Gland appears in the form of a soft movable tumor under the upper eyelid, and has been several times reported.

The *treatment* consists of extirpation of the prolapsed organ.

Fistula of the Lachrymal Gland.—This may remain on account of the rupture of an abscess, but has also been recorded as a congenital defect. When it is the latter, the orifice has been seen at the outer third of the upper lid, and in one case was surrounded by a tuft of hair.

The fistula may be closed by repeated cauterization, or by a plastic operation; in the event of the failure of these measures, extirpation of the gland is indicated.

Syphilis of the Lachrymal Gland.—The lachrymal gland is singularly free from syphilitic affections, but specific induration and inflammation have been described, and in any instance of unaccounted hypertrophy of this gland, careful anti-syphilitic treatment should be undertaken before resorting to surgical measures.

Dacryops.—This affection, often classified with diseases of the conjunctiva, is caused by a cystic distension of one of the gland ducts, and appears in the form of a bluish, translucent swelling beneath the conjunctiva at its upper and outer part. If the mouth of the excretory duct is not occluded, pressure upon the tumor causes a few drops of liquid to escape.

TREATMENT.—Incision of the walls of the cyst causes it to collapse. The wound should be opened from time to time in order to prevent too rapid cicatrization.

Tumors of the Lachrymal Gland.—Adenoma, osteoma, osteochondroma and sarcoma occur. Tubercle has also been reported in this region.

Excision of the growth is the proper remedy.

Anomalies of the Puncta Lachrymalia and Canaliculi.

1. *Congenital Anomalies.*—Double puncta lachrymalia and canaliculi have been observed as congenital anomalies. There may be congenital absence of these structures, or the lachrymal points may be wanting and the canals may be represented by furrows along the edge of the lid.

2. *Acquired Anomalies.*—The slightest change in the natural relation of the lower punctum to the eye, against which it is directed backward, causes *epiphora*,[1] or an overflow of tears.

The most fruitful sources of such abnormal relationship are the various chronic inflammations of the lid and conjunctiva—blepharitis, granular conjunctivitis, and ectropion—and facial palsy and wounds of this region. In facial palsy, watering of the eye is sometimes an early symptom, and is caused partly by the loss of the compressing power of the lid, especially in the fibres of Horner's muscle, and partly by the falling away of the punctum. An overflow of tears may follow an abnormal position or enlargement of the caruncle. All of these conditions, then, cause a *malposition* of the *punctum lachrymale.*

Epiphora is also caused by a stye or tumor of the lid near the punctum, or, if the canaliculus is closed, by the presence of a foreign body, usually a cilium; by a mass of fungus (*leptothrix*), which by becoming calcified may form a so-called *tear-stone;* or even by a *polyp.* In like manner, chronic conjunctivitis and marginal blepharitis may close either the lachrymal point or the canaliculus. These affections, then, are included under the terms *stenosis* of the *punctum lachrymale* and *obstruction* of the *canaliculus.*

Treatment.—In cases of epiphora without disease of the lachrymal sac or stricture of the nasal duct, a simple slitting of the canaliculus is usually sufficient. If a foreign body is present, this should be removed.

In some cases of epiphora which seem to depend simply upon closure of the lachrymal point, this may be opened by means of a gold or silver pin which is pushed along the canaliculus. Afterwards the permeability of the lachrymal duct may be found by inserting the point of an Anel syringe and injecting a few drops of water and observing whether it passes freely into the nose. This very simple procedure will sometimes afford great relief without the necessity of either slitting the canaliculus or

[1] Epiphora, strictly speaking, is an excessive secretion of tears, while stillicidium lachrymarum is an overflow from obstruction; but, as Mr. Nettleship remarks, no useful purpose is served by keeping the two names.

dilating the duct. If the epiphora has been caused by facial palsy, the treatment advised does not apply.

Anomalies of the Lachrymal Sac and Nasal Duct.

1. *Dacryocystitis.*—The universal symptom in affections of the lachrymal sac and nasal duct is epiphora; the eye swims in tears, and these are excited to overflow by exposure to dust, cold, or wind; the caruncle and plica are swollen; the neighboring conjunctiva is hyperæmic and injected (*lachrymal conjunctivitis*); the skin is macerated, and the margins of the lid, especially toward the nose, show signs of blepharitis.

Usually there is slight distension over the region of the lachrymal sac (*mucocele, lachrymal tumor*), and pressure upon this expresses through the puncta the retained fluid, which is a clear or semi-transparent viscid mucus (*dacryocystitis catarrhalis*), or turbid from mixture with purulent material (*dacryocystitis blennorrhoica*).

This *chronic* distension of the lachrymal sac is liable to develop into a suppurative inflammation producing *acute dacryocystitis*, which may be preceded by fever and chill; the lids and region of the nose become tense and tender to the touch, and a red and brawny swelling resembling erysipelas, for which it not infrequently has been mistaken, overspreads the region.

When there is added to disease of the sac a phlegmonous inflammation of the cellular tissue (*dacryocystitis phlegmonosa*) which surrounds it, the pus burrows in front of the sac, forms pouches in the connective tissue, and in most instances the *lachrymal abscess* thus formed points below the *tendo oculi*. If unmolested, the abscess ruptures externally with the formation of a fistulous opening into the sac, the mouth of which is surrounded by pouting granulations. (Fig. 157.)

2. *Pre-lachrymal Abscess.*—This consists of a swelling above the internal palpebral ligament and a little external to the region of the lachrymal sac, associated with a fistulous opening, from which pus flows, having no connection with the sac itself. It may be caused by a blow at the inner angle of the eye and may be associated with caries and perforation of the lachrymal bone (Bull). The same condition appears without injury in children, who are the subjects of hereditary syphilis.

The condition is to be distinguished from a true lachrymal abscess by the fact that there is no interference with the passage of tears from the conjunctiva into the sac, and by the absence of acute inflammation.

Fig. 157.



Phlegmonous dacryocystitis. Pouting granulations surround the fistulous orifice. From a patient in the Children's Hospital.

The *treatment* is that of an abscess, together with such constitutional measures as may be indicated by the dyscrasia of which the patient is the subject.

3. *Fistula of the Lachrymal Sac.*—This occasionally has been observed as a congenital anomaly, and may be present on only one side or on both sides. The opening is usually directly under the internal palpebral ligament.

Generally a fistulous opening into the sac is caused by the *rupture of a lachrymal abscess*, but it may result from a carious condition of the upper canine teeth. The opening may appear about one centimetre below the punctum, but also in various spots along a line which runs outward, parallel to the lower orbital border.

It usually communicates with the sac, but in rare instances the opening may lead into the lower canal only, the sac above being shrunken. Pus and muco-pus, and later, tears which should descend into the duct, exude from the opening, which for a long time persists as a fine orifice, at the mouth of which appears a drop of clear fluid. This is the so-called *capillary fistula.*

The condition is to be differentiated from a *buccal fistula* below the margin of the orbit, by observing that in the latter the situation is never accurately at the orbital margin, that a sound never passes upward but only downward, laterally or posteriorly, and that the secretion is always purulent.

4. *Obstruction of the Nasal Duct.*—This generally antedates the affection of the sac. It may be situated at any part, but selects by preference the point at which the nasal duct enters into the sac, or the lower end where it passes into the nasal chamber.

In the early stages of catarrhal dacryocystitis there probably is no true stricture of the duct, but the flow from the sac into the nose is prevented by swelling of the mucous tissue; later, and in other instances, dense cicatricial strictures occur.

Cause of Disease of the Lachrymal Sac and Nasal Duct.—Diseases of the lachrymal sac is rarely primary. In young infants dacryocystitis, often double, arises without apparent cause.

In the majority of cases, blennorrhœa of the sac is caused by a retention of the secretion from stricture or obstruction in the nasal duct, and the participation of the lining of the sac in an inflammation of the naso-pharynx. In other instances strictures result from, rather than cause the blennorrhœa. A proper appreciation of the pathological conditions of the nasal mucous membrane in relation to diseases of the lachrymal apparatus is of the utmost importance, and in nearly every case of disease of the lachrymal sac and of the lachrymo-nasal duct, morbid conditions of the nasal chambers and of the naso-pharynx are present.

Although it might seem natural that conjunctivitis, and especially purulent conjunctivitis, should cause lachrymal disease, this is by no means frequently the case. Conjunctivitis and blepharitis, so often accompanying disorders, follow rather than cause the lachrymal affection.

Obstruction of the duct and disease of the sac are sequels of measles, scarlet fever, and especially smallpox, because these exanthemata are accompanied by inflammation of the nasal mucous membrane.

Periostitis and caries of the lachrymal bone, the result of syphilis, are important causes. Gummy growths may block the sac and go on to rapid suppuration.

The relation between asymmetry of the face and disease of the lachrymo-nasal duct deserves mention. Traumatism accounts for certain cases. Most impermeable obstructions follow injuries and the rough use of bougies. Stoppage of the lachrymo-nasal duct may be caused by pressure from neighboring tumors; for example, in the antrum of Highmore, and by foreign bodies lodged in the lower lachrymal canal.

Fistulas, especially those seen in infants, often arise from disease of the bone, which in turn is the result of inherited syphilis.

Prognosis in Lachrymal Disease.—The well-known fact that under the most skilful treatment affections of the tear passages often resist healing, renders a guarded prognosis necessary. This depends entirely upon the condition of the nasal chambers, the duration of the malady, the permeability of the stricture, and the cause of the trouble. When the latter is the result of injury, the prognosis becomes especially grave, and the malady may be irremediable.

Character of the Lachrymal Secretion under Pathological Conditions.—The lachrymal sac is a reservoir for the fluid secreted by the conjunctiva, and this fluid is more or less loaded with micro-organisms. Observers have found in dacryocystitis *streptococcus pyogenes*, which, by inoculation, cause phlegmonous inflammation.

If the cornea is abraded, or if a solution of continuity in this membrane is necessitated by an operation, the presence of pathogenic organisms in the fluid becomes a serious complication. These may turn a simple abrasion into a sloughing ulcer or an aggravated hypopyon-keratitis. They may prevent the healing of an ordinary keratitis, and finally they may inoculate an operative wound and defeat the object of the operation.

For this reason it is most important that in any of the three conditions just quoted the permeability of the nasal duct should be ascertained. If it is strictured, it should be opened, and the walls of the lachrymal sac, if inflamed, brought to a healthy condition as speedily as possible. The importance of this relation of the

lachrymal apparatus to diseases of the cornea and to the prognosis of cataract operations has been described.

Treatment of Diseases of the Lachrymal Sac and Duct.—Manifestly the success of all treatment centres upon the restoration of the calibre of the duct, if this be strictured, and the relief of the most important cause of the disease of the sac. Occasionally, as has already been stated, it suffices to dilate the punctum and wash out the sac with a fine canula adjusted to an appropriate syringe.

Usually three procedures are necessary—slitting the canaliculus, introducing the probe into the nasal duct, and syringing the sac and naso-lachrymal duct. The method of slitting the canaliculus and the introduction of a probe is described on page 622.

After the canaliculus has been incised, the duct and the sac should be washed out thoroughly with some antiseptic fluid, either a saturated solution of boracic acid or a 1-5000 solution of bichloride of mercury. In cases where pus is present, pyoktanin (1-1000) certainly has a favorable influence.

Some surgeons, as a rule, split the upper canaliculus, although the usual practice is to approach by means of the lower passage. If there is much distension of the sac it has been suggested to enter the upper passage and incise both this and the wall of the sac.

In making use of probes, it is advisable to begin the first trial with a No. 2 Bowman probe; if this fails, a smaller one may be tried. Either rapid or gradual dilatation is employed, the latter being the preferable method. Undue efforts should never be used, as it is extremely easy to make a false passage and perforate the delicate structure of the lachrymal bone, while roughness in the use of probes by scraping off the mucous membrane may cause the most impermeable type of stricture. For this reason, in some cases it has been suggested not to use probes at all, but simply by means of a syringe introduced into the mouth of the sac, to medicate the inflamed tissue, which, as before stated, sometimes causes occlusion by swelling, without the actual presence of a cicatricial stricture.

When sounds are employed, these should be used at first every

second or third day, but as the case progresses longer intervals may elapse; the whole treatment often occupies months.

If a lachrymal abscess supervenes and is seen early, the canaliculus should at once be slit and, if possible, the secretion evacuated with retention of the passage into the nose. Frequently the pain and swelling are such as to render this impossible, and the opening must be made upon the face about 1 cm. below the palpebral tendon, cutting downward and outward. In the highly inflammatory stage, probing must not be employed, but the sac and abscess cavity should be freely irrigated with a solution of bichloride of mercury.

An excellent practice is to use hot compresses over the swelling, preferably of carbolized water, at a temperature of 120 F., frequently changed and applied for five or ten minutes at a time. Later the passage into the nose must be undertaken with probes in the manner already described, but if the patient is refractory, especially a young child, a stile made of lead wire, slightly hooked over the inner canthus to prevent its slipping into the nose, may be introduced.

Swelling over and around the lachrymal sac, together with fistulous communication into it, occasionally will subside under the judicious use of a compressing bandage.

The great difficulty that is sometimes experienced in keeping the canaliculus open has led to the employment of *electrolysis*. This is applied to the canaliculus by means of a probe fitted in a handle and connected with the negative pole of a battery, the positive electrode being placed on the back of the neck. The *seancé* should last about half a minute with a current of 2 milliampères.

In addition to the local measures already mentioned for the purpose of producing healing in cases of lachrymal disease associated with a catarrhal condition of the passages, solutions of nitrate of silver, salicylic acid, iodoform, aristol, creolin (1 per cent.) and blue pyoktanin (1-1000) have been advocated. As already stated, the latter remedy where pus is present yields good results.

In acute inflammation with abscess formation, quinine, and iron in the form of Basham's mixture, are indicated; in syphilis, with disease of the bone and gummy deposit, the usual drugs

should be exhibited; in struma, cod-liver oil, hypophosphites, and iron, in the form of the syrup of the iodide, are the most trustworthy remedies.

Scrupulous attention to the nose and the naso-pharynx is necessary, and any local lesions which present themselves must be treated. In the absence of a special line of practice for this region, excellent results follow a simple spraying of the parts with Dobell's solution and listerine, while carrying on the regulation measures for the relief of the lachrymal disorder. This, however, merely cleanses the parts, and if there is decided disease of the region, the proper treatment of the part with the view to removing diseased structures should be undertaken.

Occasionally it will happen that although a duct has been thoroughly opened, the probe passes readily and the liquid used in the syringe flows freely from the nose, none the less the epiphora continues as bad as ever and the eye fairly swims in tears. Under such circumstances a probe should be passed into the nose and the entrance of the duct into the inferior meatus properly exposed by means of a nasal speculum. Quite often it will be seen that a thickening of the duct-entrance, or perhaps a valve-like flap of mucous membrane, occludes the passage. This is pushed aside by the probe or forced aside by the liquid when it is injected, but entirely stops the flow of the tears. This simple precaution will sometimes lead to the discovery of the cause of failure to relieve cases which have stubbornly resisted treatment.

If a fistula remains, this may sometimes be healed, as already stated, by compression. In the event of failure, freshening of the edges and the galvano-cautery may be tried, the surrounding pouting granulations being removed by scraping. The capillary fistulas are productive of no inconvenience and may be allowed to remain undisturbed.

In stubborn cases which have defied all reasonable treatment, extirpation of the lachrymal gland has been performed, or, as more recently advocated, excision of its palpebral portion. In other cases, the lachrymal sac has been obliterated by means of caustics. Under judicious treatment the necessity for these somewhat heroic measures ought not to arise.

CHAPTER XXI.

DISEASES OF THE ORBIT.

Congenital Anomalies.—*Anophthalmos*, or complete absence of one or both eyes, is an affection which, like the other congenital anomalies, is more frequently observed to be double than one-sided. A child born without eyes may be healthy and well developed in other respects, or may be the subject of additional congenital deformities. The palpebral fissures are small, the lids usually deficient in size, sunken, and upon their separation the empty orbit without trace of the globe is revealed.

The most reasonable explanation of this anomaly is that no primary optic vesicle has budded out from the anterior primary encephalic vesicle, or, that having budded out, it has failed to form a secondary optic vesicle. In some instances the absence of the globe is not complete, but a cyst appears in the lower lid, in the interior of which is found a misplaced rudimentary eyeball.

Microphthalmos and *Megalophthalmos* are anomalies of the globe to which reference has been made.

Cyclopia is a congenital malformation characterized by a fusion of the orbits and the two eyes in the middle of the face, so that there is only one eye situated in the place normally occupied by the root of the nose.

General Symptoms of Orbital Disease.—Two symptoms are so constantly present that they may be said to be essential to the clinical picture of most of the affections of the orbit.

(1) *Proptosis or Exophthalmos.*—This consists of more or less protrusion and displacement of the globe.

(2) *Immobility of the Eyeball.*—This may be complete or partial, and, if vision is unaffected, the limitation of the movements of the eye is associated with diplopia. Complete immobility may be differentiated from a similar condition due to palsy of all

external ocular muscles (ophthalmoplegia externa) by the absence of ptosis (Noyes).

Less universally present, the following signs may be associated with orbital disease :—

(a) *Chemosis of the Conjunctiva*, either universal or else localized upon a special portion of the globe, indicating the neighborhood of the diseased area.

(b) *Redness, Swelling and Œdema* of the eyelids, especially in the inflammatory affection of the cellular tissue of the orbit.

(c) *Pain*, most noticeable when the patient attempts to move the eye, or when the surgeon palpates the globe and presses it inward. In addition to the pain in the orbit itself, *frontal headache* is a common symptom, especially when the frontal sinus is involved, and *tenderness on pressure* along the margin of the orbit and accessible portions of its walls is one sign of disease of the periosteum.

(d) *Fluctuation* occurs, but not constantly, when an abscess of the orbit has formed.

(e) *Disturbance of Vision.*—In some cases of orbital diseases there is no disturbance of vision : in others there may be marked changes in the eye-ground—papillitis, atrophy, hemorrhages and vasculitis.

Periostitis.—Periostitis of the orbit is both *acute* and *chronic*, and in the acute type appears either as a *localized* affection, or as a *diffuse* suppurative process.

The *symptoms* of acute localized periostitis are pain, tenderness over the seat of the disease, usually the margin of the orbit, injection and chemosis of the conjunctiva, and some swelling of the lids and protrusion of the ball. In the diffuse variety of the disease all the foregoing symptoms are much aggravated, and there may be in addition fever, general headache, delirium and stupor. In such a case the differential diagnosis between it and an orbital cellulitis becomes extremely difficult. In fact, the cellular tissue is associated with the periosteum in the inflammation.

In chronic periostitis there are deep-seated pain, often worse at night, tenderness on pressing the eyeball backward, thickening of the tissue beneath the orbital margin and swelling of the lids

and conjunctiva, although the latter symptoms, together with proptosis, may be absent.

According to Mracek, syphilitic periostitis most frequently attacks the orbital margins, and may occur in a *gummatous* or a *sclerosing* form. It less commonly involves the orbital walls behind Tenon's capsule, and is then generally gummatous in type. The site is usually in the upper or outer wall, and the disease causes trigeminal neuralgia, worse at night, and restriction in the mobility of the globe, with squint and diplopia. Optic neuritis may occur.

Causes.—The causes of periostitis, especially of the chronic form, in addition to syphilis, in which disease it is sometimes a secondary but more often a late manifestation, are rheumatism, scrofula, and injuries.

The *prognosis* depends upon the type of the disease. If localized, this is favorable; if diffuse and suppurative, not only may extensive implication of the tissues surrounding the globe leave permanent disabilities and deformities (exophthalmos, muscle-palsy, optic atrophy, necrosis), but the inflammation may extend to the meninges of the brain and cause death.

Chronic periostitis may last for months, and in any type fistulæ, necrosis and caries of the bone are the common result. Periosititis due to syphilis presents the most favorable prognosis.

Treatment.—The constitutional treatment depends upon the cause, and includes the iodides and salicylates in rheumatic cases, and the free use of mercurials and iodide of potash in syphilitic cases. Scrofulous patients should be given suitable remedies.

The surgical treatment of acute periostitis consists in an incision into the affected area and evacuation of the pus; in short, the treatment is the same as that applied to acute periosteal disease elsewhere located.

Caries and Necrosis.—Caries is prone to attack the margin of the orbit, especially the lower and outer part, and may be due to syphilis or scrofula. An injury often is the exciting cause in scrofulous cases.

The *symptoms* of periostitis are present, suppuration develops, the abscess comes to the surface through the lid over the diseased area, rupture occurs with the discharge of pus, a fistula forms

surrounded by granulations, and through this a probe will detect the softened bone. Very decided deformity of the lid may be occasioned, most commonly in the form of an ectropion (compare Fig. 78).

Caries of the orbit is most common in children, and, as has been pointed out, selects the margin of the orbit for its site, although it may occur in the roof, in which case it becomes a complication endangering life, owing to the proximity of the brain.

Necrosis of the orbit is much less common, and its immediate cause is an osteitis occurring as a consequence of acute periostitis. A fragment of bone completely separated by a fracture from the periosteal surroundings would probably undergo necrosis, and the rough use of probes may cause mortification of the delicate lachrymal bone. Necrosis, unlike caries, is more common in adults.

Treatment.—This consists of the remedies recommended in the treatment of periostitis, and, as caries is a very chronic affection and most common in strumous subjects, cod-liver oil, phosphates, iodide of iron, and Lugol's solution should be included in the constitutional measures, and should be exhibited for long periods of time.

The local treatment during the early ulcerative stage of caries consists in keeping the parts clean with an antiseptic solution. Later, an attempt may be made to dissolve the diseased bone by the use of acids. For this purpose dilute hydrochloric and dilute sulphuric acid have been recommended, applied directly to the carious area. Considerable caution is necessary before resorting to the removal of the diseased bone by a gouge, because the process is essentially chronic and may be aggravated by the manipulations of the instrument. The carious bone should have reached the surface before an attempt is made to remove it. If the roof of the orbit is affected, great care is necessary lest the cranial cavity be penetrated. If a piece of the orbital wall has undergone necrosis, this may be removed when it has become detached.

Cellulitis (*Phlegmon of the Orbit*).—Under this term are included several varieties of inflammations of the cellulo-fatty tissue

of the orbit. Thus the inflammation may be acute, subacute, or chronic, monolateral or bilateral, and finally it may undergo resolution, or, as more commonly is the case, terminate in suppuration.

In the *mild* form, the *symptoms* are dull pain, slight swelling of the lids, slight exophthalmos and diplopia, without inflammatory symptoms and without constitutional disturbance.

In the *acute* phlegmonous variety of the disease, there are chills, fever, deep-seated pain, most marked upon attempting to move the eyes, general headache, exophthalmos, limitation in the movements of the eye (which may become entirely fixed), and swelling and œdema of the lids, together with hyperæmia and chemosis of the conjunctiva. The last two symptoms are so severe at times as to give at first sight the general impression of a violent attack of blennorrhœa. (Fig. 158.)

Fig. 158.



From a photograph of a patient, in the Philadelphia Hospital, suffering from double orbital cellulitis, the result of erysipelas.

In the earlier stages, vision is not usually affected, but later there may be optic neuritis followed by atrophy, dilatation of the pupil, anæsthesia, and even ulceration of the cornea, and, indeed, in bad cases the eyeball may pass into suppuration. In certain types of orbital cellulitis, extensive intraocular changes occur, with hemorrhages and vascular alterations, due to compression of the central vessels of the retina producing stoppage of the circulation and œdema and exudation into the retina (Knapp). Fluctuation finally develops, and pointing usually occurs below the inner portion of the supraorbital ridge.

The symptoms of *chronic* abscess are much less violent and distinctive than those just described. They may, indeed, be mistaken for other morbid conditions, especially as the abscess

is commonly associated with diseased bone or periosteum in scrofulous subjects, or may occur in them from an injury or the presence of a foreign body.

Causes.—The causes of orbital cellulitis are various. It may be idiopathic and be due to exposure to cold; it may follow in the wake of certain fevers, as scarlatina, or typhoid fever; or it may be the result of a meningitis. The most violent types of orbital cellulitis occur with facial erysipelas. In these instances, the affection is usually double. The extension of inflammation from diseased teeth or suppuration in the ethmoidal cells has been known to cause the affection. Finally, a certain number of cases are metastatic, and develop in the course of pyæmia, especially puerperal septicæmia. The association of orbital cellulitis with periostitis has already been referred to, and a certain amount of cellulitis occurs whenever there is a general inflammation of the globe.

Progress and Prognosis.—In mild cases the prognosis is favorable; in severe cases, very unfavorable; and in double cases, especially those which have originated under the influence of erysipelas, fatal. Although the pus may make its exit through the conjunctiva, it may also pass backwards through the sphenoidal fissure. In pyæmic cases, and indeed in the course of any severe inflammation of the cellulo-fatty tissue of the orbit, *phlebitis of the orbital veins* may become a complication and extend to the cavernous sinus, leading to a fatal encephalitis. If the disease passes to the cavernous sinus upon the opposite side, the other eye also becomes involved and exophthalmos is evident.

In making up a prognosis it is necessary to consider the effect of the disease upon the eyesight and upon the life of the patient. Sight may be impaired or destroyed by the development of neuritis, atrophy, and exudation and hemorrhages into the retina, or by suppuration of the cornea; life may be endangered by an extension of the suppurative process into the cranial cavity, or by the original malady, which caused the cellulitis.

Treatment.—The general treatment should include supporting measures and iron and quinine, the last, however, with caution if there is a suspicion of meningeal complication. Locally, frequently changed hot compresses are proper, and in the early

inflammatory stages, bleeding from the temple. As soon as there is the slightest suspicion of pus, incisions should be made, multiple if necessary, and preferably from the conjunctiva. Proper drainage having been secured, the discharging passage should be frequently syringed with an antiseptic solution.

In the opinion of the best surgeons it is not necessary to wait for an actual pointing before making use of a knife to evacuate pus, lest the delay cause serious complications from the compression of the tissues within the orbit (Noyes). If the abscess has manifested itself by pointing, the incision is made with the knife introduced flatwise at the point of greatest fluctuation. A sinus may persist after the evacuation of an orbital abscess, especially one of the chronic type. This may be stimulated to heal by the use of astringent and antiseptic injections.

Inflammation of the Oculo-Orbital Fascia (*Tenonitis*).—This affection is characterized by swelling of the upper lid, pain on the slightest movement of the eye, some proptosis and limitation of movement, together with the appearance of a watery nodule or vesicle situated over one of the recti muscles; in other cases the chemosis may be more general. The affection may be idiopathic, or may follow an injury or an operation, for instance, strabotomy; in some instance it is due to rheumatism, and it has been a sequel of diphtheria and epidemic influenza.

The treatment should consist of warm fomentations and, according to the indications, iodide of potash or the salicylates.

Thrombosis of the Cavernous Sinus.—During phlegmonous inflammation of the orbit there may be thrombosis of the orbital veins, and extension from them to the cavernous sinus or to the other sinuses of the brain.

Thrombosis of the cavernous sinus itself, however, as the result of some intracranial lesion, produces symptoms which are very like those of cellulitis of the orbit. This disease belongs more truly to the domain of neurology, but is extremely interesting on account of the ocular symptoms which accompany it.[1]

[1] Those interested in the subject of disease of the cavernous sinuses should consult Transactions of the Ophthalmological Society of the United Kingdom, Vol. V., 1886–1887, pp. 228–234, and Philadelphia Hospital Reports, Vol. I., 1890, pp. 261–269.

Tumors of the Orbit.—These have been divided by systematic writers into those which originate in the orbit, but are unconnected with the globe of the eye; those which arise from the periosteum or bony walls of the orbit; those which commence in the cavities close to the orbit; and those which originate in some vascular disease within the cavity of the orbit or the neighboring portions of the cranial cavity, and which usually lead to the symptom of *pulsating exophthalmos.*

Two classes of tumors, namely, those which arise from the optic nerve, and those which arise from the lachrymal gland, are sometimes included among the orbital growths. They have already been discussed in another section.

The *nature* of orbital tumors is either benign or malignant, and they may be congenital or acquired, primary or metastatic.

The *symptoms* which indicate the presence of a tumor of the orbit vary according to its position, size and density, but in general terms are those which have been narrated as more or less common to all diseases of the orbit. With regard to the protrusion it may be said that a tumor within the cone of the recti muscles is apt to cause a forward displacement of the globe, while one situated outside of this cone may displace the eyeball in some particular direction (Berry).

Considerable proptosis may occur under the influence of an orbital tumor without causing the globe to protrude between the fissure of the lids. This is due to the fact that the lids are extensible and accommodate themselves to the increasing volume behind them; finally, however, in bad cases the protrusion is so great that the lids can no longer close over the prominent ball.

The *prognosis* depends upon the nature of the tumor, the density of its tissue, the rate of its growth, and the availability of surgical interference.

The *treatment* of morbid growths of the orbit, except of those which originate in some vascular disease, consists in their removal according to the rules of general surgical practice. In dealing with benign tumors, the eyeball, if uninvolved, should be allowed to remain, if possible; but in malignant tumors it should be excised, in most instances, with the entire contents of the orbit.

1. *Tumors which Originate in the Tissues of the Orbit.*—These include cysts (sebaceous and dermoid cysts, echinococci and cysticerci), cavernous and simple angiomas, lipomas, enchondromas, lymphomas, and various types of sarcoma. Carcinoma, except in connection with the lachrymal gland, does not occur here as a primary tumor.

Sarcomas of the orbit should not be confounded with those which arise within the eyeball and have burst their boundaries (page 358).

Occasionally a simple incision suffices to cure a cyst if the cavity is afterwards frequently syringed with an astringent or antiseptic lotion. If semi-solid or solid contents are present, entire removal is necessary. Care must be taken not to confound an encephalocele with an orbital cyst.

2. *Tumors which Arise from the Periosteum or Bony Walls of the Orbit.*—These include :—

(a) *Sarcomas,* which arise from the periosteum.

(b) *Thickening of the Periosteum,* which may simulate a true tumor, especially if the underlying bone is hypertrophied (hyperostoses : these may be multiple or diffuse), and—

(c) *Exostoses.*—The latter are very hard tumors having an ivory-like shell and a nucleus of spongy bone, their anatomical structure in general being like those of the osteomas proceeding from adjacent cavities.[1] All orbital osteomas grow slowly—the external exostoses more slowly than the bony tumors which originate from the frontal and ethmoidal sinuses. They spring from the periosteum, and are generally found at the upper border of the orbit, although they may occur at any portion of the orbital border, and are recognized by their dense hardness, and evident connection with the bone.

They may arise from injury ; sometimes they are congenital, and often their origin is obscure.

The operation for the removal of an exostosis consists in drilling it away at the base and completing the separation by means of a hammer and chisel. The operation is attended with considerable risk.

[1] For a valuable paper by J. A. Andrews, on Osteomas of Orbit, see Medical Record, September 3, 1887.

3. *Tumors which Arise in Cavities or Tissues Close to the Orbit.*—These include:—

(a) *Encephalocele*, a very rare condition, which appears in the form of a somewhat pulsating, fluctuating protrusion at the inner angle of the orbit; it is of congenital origin.

(b) *Nævi*, *epithelioma* and *lupus*, which may extend from the skin of the face into the orbit.

(c) *Polypi* from the nasal chambers and surrounding sinuses, and

(d) *Osteomas* of the frontal and ethmoidal sinuses.

An *osteoma* consists of a dense growth, with predominance of the ivory-shell, and only a trace of spongy tissue (occasionally the reverse occurs). Generally the surface is covered with a delicate connective tissue envelope, and part of this may be the seat of polypoid growths coming from the remains of the mucous membrane which atrophies under pressure of the tumor.

According to Andrews, osteoma of the frontal sinus first makes its appearance by a tumor at the upper inner angle of the orbit, and may be associated with the formation of polypi and suppuration of the sinus.

One which grows from the ethmoidal sinus first appears at the inner angle of the orbit, and the eyeball is displaced laterally.

If an osteoma springs from the antrum of Highmore, the tumor appears behind the lower eyelid, and the eyeball is displaced upward; if it arises in the sphenoidal fissure, sight is affected by compression of the optic nerve.

Extirpation of osteomas in the sinuses is attended with considerable risk, and a number of fatal cases are upon record.

4. *Tumors which Originate in some Vascular Disease within the Cavity of the Orbit, or in the Neighboring Portions of the Cranial Cavity* (*Pulsating Exophthalmos*).—Under the name pulsating exophthalmos, a number of conditions have been recorded which have in common the symptoms described by the term just employed, namely, protrusion of the eyeball, with pulsation. In addition to this, a distinct bruit can be heard over the eye and the forehead. The vessels of the eyelids and also those of the retina are unduly distended. Stooping forward increases the protrusion, the fulness of the vessels, and the pulsation. The subjective symptoms are tinnitus aurium, noises in the head, and

pain, all of which may be modified by pressure upon the carotid artery, a procedure which also causes the protruding globe to recede.

Formerly symptoms such as these were regarded as evidence of true aneurism of the ophthalmic artery, but pulsating exophthalmos may also be due to a vascular tumor or to an intracranial disease, such as inflammation of the sinuses. The orbit may be the seat of ordinary aneurism affecting the ophthalmic artery, of traumatic aneurism, or of aneurism by anastomosis. In either of the two first named conditions, exophthalmos and pulsation would be present, but the same symptoms may be produced by extraorbital aneurism of the ophthalmic artery, aneurism of the internal carotid, aneurismal varix involving the internal carotid and the cavernous sinus, and dilatation from obstruction of the ophthalmic vein. Aneurism by anastomosis may involve the orbit by spreading from neighboring parts, and is not accompanied by exophthalmos.

Treatment.—The medicinal treatment of aneurism with low diet and iodide of potash may be tried, but in most instances the effectual means are electrolysis, compression of the carotid, either constant or intermittent, or its ligature. It has been suggested to employ electrolysis in association with intermittent compression of the carotid. A few cases of spontaneous cure are said to have occurred.

Exophthalmic Goitre (*Graves's Disease, Basedow's Disease*).—This disease, when it is perfectly developed, is characterized by three cardinal symptoms—enlargement of the thyroid gland, palpitation of the heart, and prominence of the eyeballs. As the affection should be classified with diseases of the nervous system, the student is referred for a full consideration of the subject to treatises upon this branch of medical practice.

Inasmuch, however, as one of the cardinal symptoms—prominence of the eyeballs—is a very marked one, and as there are certain changes seen especially in and around the eyes, a few words may be added. Exophthalmos varies from a mere prominence of the eyeballs, such, for instance, as is noticeable in a highly myopic globe, to a degree of protrusion so great that the

eyelids are unable to close. Three symptoms should be searched for :—

(1) *Von Graefe's Sign*, which is very important in the early recognition of the disease. Normally, when the globe is turned downward the upper lid moves in perfect accord with it; in this disease, on rolling the eyeball downward the movement of the upper lid is no longer in accord, follows tardily, or does not move at all. The symptom is not always present, but it may be noted prior to any exophthalmos or at least when there is only a very trifling degree of this, and it persists after the protrusion of the eye has subsided.

(2) *Stellwag's Sign*.—This consists of imperfect power of winking or diminished frequency in the act; thus, there may be a number of rapid winks succeeded by a long pause in which there is no movement of the lids, or each time that nictatation occurs, it is not complete and the margins of the lids do not, as in the normal eye, come together.

(3) *Dalrymple's Sign* (Cooper-Swanzy).—This consists of retraction of the upper eyelid so that there is an unnatural degree of separation between the margins of the two lids. The widening of the palpebral fissure produces the peculiar stare which is present in the subjects of exophthalmic goitre, and which has been compared to a similar appearance produced by the action of cocaine.

Changes in the Cornea.—The exposure to which the eye is subject and also the paralysis of the nervous supply may cause drying of the epithelium, and ulceration of so violent a type as to produce destruction. New vessels may develop in the lower part of the cornea on account of its exposure through the widened palpebral fissure. These corneal changes necessarily occur in severe types of the disease where the protrusion of the eyeballs has been considerable.

Ophthalmoscopic Changes.—These are not commonly present to any great degree except in so far as a change in the size of the retinal vessels is concerned. The arteries may be dilated and assume a calibre larger than normal and equal to that of the veins. Spontaneous arterial pulsation is frequently present (Becker). Alterations in the optic nerve and in the general fundus are not

usually found, and there are no changes in the eye-grounds characteristic of the disease.

Nature of the Disease.—The theory which has ascribed Graves's disease to a lesion of the cervical sympathetic causing paralysis of the vaso-motor nerves, does not at the present time receive the support that it formerly enjoyed ; and while the pathology still remains quite obscure, the evidence thus far tends to show that the disorder depends upon a central lesion.

Treatment.—For the general treatment of exophthalmic goitre the student is referred to the text-books on general medicine and neurology. If ulceration of the cornea occurs, the usual treatment is applicable. To prevent the exposure of the cornea, the widened palpebral fissure may be narrowed by the operation of tarsorrhaphy. (See Fig. 168.)

Affections or Diseases of the Adjacent Cavities.—In discussing tumors of the orbit, it was noted that growths from the frontal sinuses, the sphenoidal fissure, the ethmoidal cells, and the antrum may encroach upon the orbit. In addition to the morbid growths there remain to be briefly considered :—

(1) *Disease of the Frontal Sinus.*—This is most often a distension of the frontal sinus by mucus (*mucocele*) or pus (*empyema*). Abscess has been attributed to post-nasal catarrh, syphilis, tuberculosis, and periostitis, and is due to the stoppage of the normal outlet, thus causing the accumulation of secretion until the sinus becomes filled, its walls distended and thin, and a tumor presents, usually at the upper and inner angle of the orbit. It may occur under the influence of erysipelas, acute infectious diseases, and epidemic influenza. Frontal headache is a common and somewhat characteristic symptom, and is said to be never absent.[1] The protrusion may cause displacement of the eyeball and diplopia, and the pressure upon the lachrymal sac, epiphora. In rare instances the abscess in the sinus is bilateral.

It is a chronic disease and occurs at any age except before the sixth year, because the sinus is not developed until after that time of life. It is most frequent between twenty-five and thirty, and commoner in men than in women.

[1] Bull has seen cases unassociated with head-pain.

The treatment consists in opening the abscess and washing out the sinus with a bichloride solution. The incision may be made immediately beneath the superior orbital arch, directly outward, so that the bony wall of the sinus, which is here very thin, may be easily opened, if it has not already perforated (Bull). The contents of the cavity should be carefully removed. The re-establishment of the communication between the sinus and the nose is also advised.

2. *Ethmoiditis* with suppuration in the ethmoidal cells may give rise to an abscess of the orbit and present in the form of a tumor, at the upper and inner corner of this cavity.

Injuries to the Orbit.—These include fracture of its bony walls, penetrating wounds, the lodgment of foreign bodies, and contusions. The effects of an injury to the orbit depend very much upon the character of the wound and missile which has produced it. The injury may lead to a phlegmonous inflammation, to hemorrhage within the tissues, and to loss of sight by rupture to the eyeball or injury to the optic nerve. There is likely to be, according to the circumstances, exophthalmos, displacement of the eyeball, and diplopia.

Hemorrhage in the orbit, especially beneath Tenon's capsule, will be referred to again as an accident which complicates strabismus operations. It may also occur in the course of certain diseases, *e. g.*, scorbutus and hæmophilia.

Treatment.—After a penetrating wound, a careful search for a foreign body should be made. In a number of instances very extraordinary foreign bodies have been found in the orbit, and, curiously enough, very remarkable toleration of the presence of such bodies. If the penetrating wound has cut off the attachment of one of the ocular muscles, and the case is seen soon enough, an endeavor should be made to suture the detached ends. In cases of excessive hemorrhage within the orbit it may be necessary to make an incision and remove the escaped blood.

Dislocation of the Eyeball.—The eyeball may be luxated from between the lids, which are then contracted behind it. It is a rare form of injury. The result of such an accident may be laceration of the optic nerve and destruction of sight. In other instances the vision has remained unaffected. In certain

cases of exophthalmos it is possible to produce this dislocation by pressure upon the globe with the thumbs, the relaxed muscles permitting the eyeball to protrude between the lids.

The *treatment* consists in replacement of the eye and the application of a pressure bandage. In order to facilitate the reduction, it has been recommended to divide the external commissure and afterwards close the wound with sutures.

Enophthalmos, or retraction of the eyeball, occurs both as an idiopathic and a traumatic affection. The enophthalmos which has been seen as the result of exhausting diseases is more apparent than real, but true backward dislocation of the eyeball is reported as the result of a traumatism, or because the globe has been caused to retract under the influence of cicatrizing bands. It is met with in cases of fracture of the bones of the orbit and absorption of the orbital fat. Occasionally the retraction of the ball immediately follows the injury, as in an interesting case described by Hansell, who reviews the meagre literature of the subject.

CHAPTER XXII.

OPERATIONS.

The character of the tissues involved in many eye operations precludes the propriety of employing powerful germicides in the manner in which they are used by general surgeons, but all the principles of clean surgery and the main practices of antiseptic surgery are applicable in ophthalmic operations. The following directions will be found useful. The general rules, based upon those given by Dr. J. William White to his students, have been modified to suit operations upon the eye :—

Preparation of the Hands of the Operator.—Scrub the hands thoroughly with soap and warm water; then clean the spaces beneath and around the nails; soak the hands in 95 per cent. alcohol for not less than one minute; on removing them place them without drying in a solution of 1-1000 corrosive sublimate, and then allow them to remain there for at least one minute.

Preparation of the Skin of the Region of Operation.—The skin should be treated first with soap and water, then with alcohol, and finally with corrosive sublimate (1-1000) or a solution of 1:20 carbolic in 1:500 bichloride. The irritating substances must not enter the conjunctival sac, but the face, surface of the closed lids, eyebrows, brow and scalp should be thus prepared. The ciliary margins should be carefully cleansed with soap and water, followed by bichloride of mercury (1-5000). The parts should be kept covered with a towel soaked in the bichloride solution until the operation begins.

The preparation of the conjunctival sac depends upon the nature of the operation; if this, for example, is an enucleation, the ordinary rules of antiseptic surgery are applicable, and the same is true, for instance, in an advancement, save only that the strength of the bichloride solution commonly employed by general

surgeons must be decreased. A solution of one grain to the pint will suffice. The preparation of the conjunctiva preparatory to cataract extraction is described on page 605.

Preparation of the Instruments.—All coarse instruments such as hooks, scissors, etc., should be cleansed first with soap and water, then boiled, and finally placed in an antiseptic bath, where they remain until required, and they should not be in this fluid for less than twenty minutes before the operation. The antiseptic bath may be carbolic acid (1-20), or absolute alcohol, preferably the latter.

Sharp instruments—cataract knives, keratomes, cystotomes, etc.—must be cleansed with great caution lest damage be done to their edges. First the edge of the instrument is inspected with a magnifying glass, then the instrument is put into boiling water and from this transferred to a dish containing absolute alcohol. When the operator is ready, it is removed from this fluid and the blade freed from the alcohol, which is irritating, by dipping it momentarily into a vessel containing boiling water. Perfect sterilization of non-cutting instruments may be obtained by having them made of platinum and bringing them to a white heat in the flame of a lamp just before the operation (Gruening). Finally, sterilization of all instruments, and also of all dressings may be accomplished by means of heat in especially devised sterilizing apparatus.

Dressings.—The usual applications must be modified according to circumstances. In plastic operations about the lids the ordinary antiseptic dressing is applicable: iodoform, protective and antiseptic gauze, covered by a wet or dry bichloride roller, although some surgeons (Noyes) prefer not to use iodoform in these cases. The various dressings used after cataract extraction will be described in another section.

When the eye is bandaged either the single or double monocle is employed, or a modification of Liebreich's bandage. In many cases a dry, absorbent material (gauze or cotton), sterilized by heat, is most useful.

Sutures.—These may be of catgut or of silk; the latter should be black, ordinarily known as iron-dyed, as white silk is not so easily seen when the time comes for the removal; for instance,

from the conjunctiva. Before their use they should be placed in an antiseptic bath.

Catgut especially prepared by the instrument makers may be

Fig. 159.



Figure-of-eight of one eye.

Fig. 160.

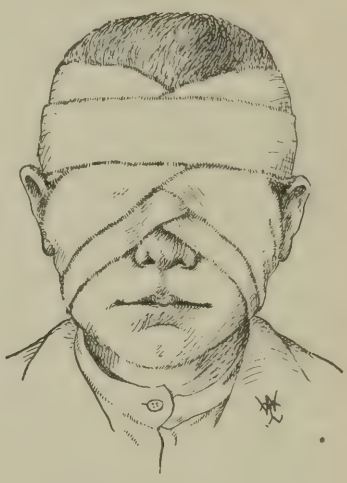


Figure-of-eight of both eyes.

Fig. 161.



Modified Liebreich's bandage.

purchased, but it is better for the surgeon to prepare this for himself.

Sponges may be needed in plastic operations or in enucleations. They should be properly prepared. Generally the area of operation may be kept clear by gently touching it with cotton soaked in a bichloride solution, or with gauze which has been sterilized by heat.

Anæsthesia.—The indications for general anæsthesia in ophthalmic surgery are limited. In children or in very nervous adults, and for enucleations, blepharoplastic operations, advancements of the muscles, and in some cases of glaucoma, general anæsthesia is necessary. The surgeon must decide between ether and chloroform. As the former is certainly safer than chloroform, or the mixture of chloroform, ether and alcohol, its use is to be preferred.

Cocaine may be employed in two or four per cent. solution, and should be freshly prepared, two per cent. of boric acid being added to the mixture. In lid operations it may be injected beneath the skin. In the operation of curetting lupus and similar growths stronger solutions (10 per cent.) are advised. The influence of cocaine upon the cornea, causing drying and roughening of its epithelium, may be partly avoided by keeping the lids closed after each instillation. Some surgeons prefer to use gelatine discs impregnated with cocaine instead of the solution.

Operations upon the Eyelids.

Epilation of the Eyelashes.—Removal of the lashes is performed with forceps, known as *cilium forceps.*

Fig. 162.



Cilium forceps.

The patient being seated in good light the operator with the fingers of one hand puts the lid upon a stretch, at the same time slightly everting its border. The faulty cilia are firmly seized and pulled out with a quick motion. After those which are readily seen have been

removed, search should be made (with a loupe) for others which may have been broken off, leaving small but irritating ends, and for very fine white hairs which, owing to their lack of color, may escape detection.

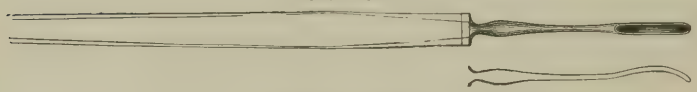
Removal of a Meibomian Cyst.—This may be removed by a conjunctival incision. A sharp scalpel and small curette are required.

Fig. 163.



Small scalpel.

Fig. 164.



Chalazion curette.

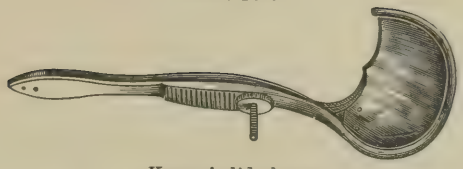
The lid is everted, and the discolored patch marking the position of the chalazion is made prominent. This is then incised, and the contents are scraped out with the curette. The cavity thus formed fills with blood, the absorption of which may be hastened by the use of hot compresses. This operation may leave a slight linear scar in the conjunctiva.

To avoid this the lid may be grasped between the thumb and forefinger, and by pressure a drop of the jelly-like contents made to appear at the mouth of the Meibomian duct. A few drops of cocaine solution are injected by means of a hypodermic syringe which is pushed into the tumor along the duct. An incision is now made with a Graefe knife following the course of the needle. A small curette is introduced and the contents of the cyst are removed (Agnew-Ray.) The subsequent blood clot is absorbed.

Although it is universally advised to remove ordinary chalazia from the conjunctival side, a certain number of *external* chalazia are more effectually treated by incision through the skin.

The lid is secured in a clamp (Fig. 165), an incision is made over the tumor, along the line of the muscle fibres and in the natural crease of the lid, and the growth is thoroughly but gently detached from its surroundings on each side, and then, being lifted by means of a small hook, it is separated from its base, care being taken not to perforate the conjunctiva. One or two black silk sutures are used to close the wound and a compress bandage is applied. If this dissection has been neatly done no perceptible scar results, and return of the growth, which occasionally happens, is avoided. Pain may be alleviated by injecting into the skin of the lid some drops of a 4 per cent. cocaine-solution.

Fig. 165.



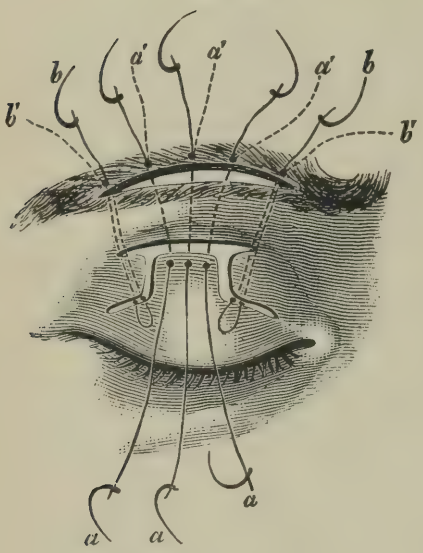
Knapp's lid clamp.

Operations for Ptosis.—The simplest operation for ptosis consists in removing an elliptical portion of the skin of the drooping lid, together with the hypertrophied subcutaneous fat and connective tissue, and, in paralytic cases, the subjacent muscle of the lid. The portion which is to be removed is held between two forceps, the one being intrusted to an assistant, and the tissue is cut away with scissors; afterwards the edges of the wound are transversely approximated. The effect of this operation is often slight and disappointing.

Good results will usually follow the operation of Panas, a description of which follows:—

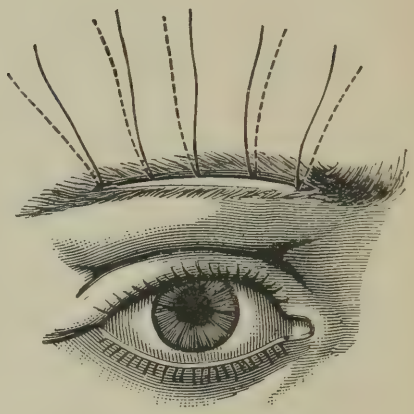
The upper lid being steadied by a horn shield, an assistant applies his hand to the brow of the patient to prevent the integument from being drawn down by the surgeon and thus disturbing the relation of the different layers. An incision is made from one canthus to the other, interrupted in its middle to the extent of 8 mm. This incision follows the furrow of separation between the tarsus and the orbital portion of the eyelid. A second horizontal incision, having its convexity upward and about 2.5 cm. in length, is made just over the orbital margin, and cuts through all the tissues down to the periosteum. Two vertical incisions join this with the inner extremity of the external portion and the outer extremity of the internal portion of the lower incision. A final incision is then made immediately above the eyebrow, the upper edge of which it follows to the extent of about 2 cm. This incision must cut through all the tissues down to the periosteum. The small cutaneous flap which has been included in the incisions on the lid, and which is evident by a glance at the picture, is dissected free down to the ciliary border. The bridge of tissue between the middle and the upper incisions is then undermined, care being taken not to injure either the suspensory ligament or the periosteum. The dissected flap is then pressed underneath this bridge of tissue and attached by three sutures to the upper edge of the upper incision and the divided fibres of the occipito-frontalis muscle. Two additional lateral sutures are applied in the manner shown in the cut. (Figs. 166, 167.) These lateral sutures are placed to prevent the drag-

Fig. 166.



Panas's operation for ptosis.

Fig. 167.



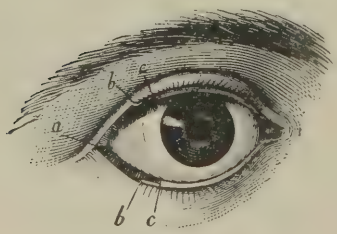
Appearances after the operation is completed.

ging which the middle flap might exercise, and thus produce ectropion. These sutures are passed through the suspensory ligament and the conjunctiva and are attached to the upper margin of the upper incision; they must not pass through the skin of the lid. The wound should be dressed with a full antiseptic dressing, and the sutures may be removed from the fourth to the seventh day, according to the firmness of the union.

Tarsorrhaphy.—This operation is performed to shorten an abnormally wide palpebral fissure. The steps are as follows:—

The external commissure is taken between the thumb and index finger, the fissure of the lids closed to the required amount, this being marked with an aniline pencil. A horn spatula or shield is now introduced between the lids and a flap removed from the free margin of each lid near the external commissure; this must contain all the hair follicles. The breadth of the flap is one millimetre and the length about four millimetres. To obtain still firmer union the ciliary margin may be denuded for several

Fig. 168.



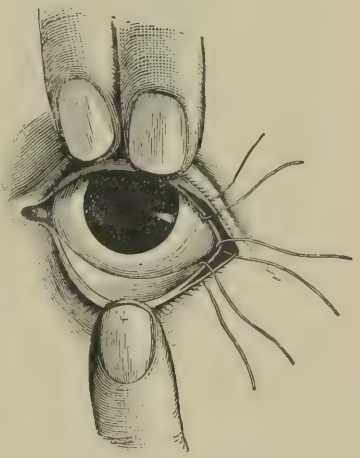
Tarsorrhaphy (Meyer).

millimetres beyond the point of removal of the flap, but in this incision the cilia must not be injured. The edges are approximated by silk sutures. The accompanying figure explains the steps (Fig. 168): *a* indicates the point of union of the two flap wounds behind the commissure; *b b* the termination of the flap wounds in the lid margins; and *c c* the end of the denudation of the ciliary margins.

Canthoplasty.—This operation is performed to enlarge an abnormally short palpebral fissure.

One blade of a probe-pointed scissors is introduced behind the external commissure, and the entire thickness of the tissues is divided, making the wound in the skin a little longer than that in the conjunctiva. The wound margins are now separated, and the surgeon loosens the conjunctiva at the apex of the incision and frees it from the underlying tissue. Three sutures are passed, one uniting the extremity of the conjunctival flap to the centre of the skin incision, and one suture above and one below near the angles of the wound.

Fig. 169.



Canthoplasty (Meyer).

Operations for Trichiasis.—If only a few hairs are involved, or, as a temporary matter, the offending lashes should be extracted with cilium forceps in the manner already described.

If but one or two lashes are involved, an operation consisting of drawing the misplaced cilia under the skin of the eyelid, by means of a fine ligature, and thus mechanically altering the direction of their growth, has been advised.

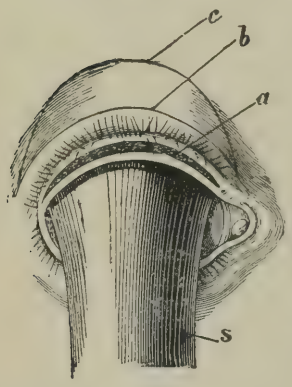
The bulbs of a few faulty eyelashes may be destroyed by electrolysis, or if the means for this are not at hand, a fine needle heated to a white glow will answer the purpose.

For complete distichiasis some form of transplantation should be employed.

One of the most useful procedures is the Jaesche-Arlt operation, which is performed as follows:—

The lid is fixed with a Knapp's or Snellen's clamp (see Fig. 165), or steadied upon an ivory shield placed beneath it, and its intermarginal portion is split by a first incision into two layers, the anterior containing all the hair bulbs. A second incision is made 5 millimetres from the margin of the lid, while a third is carried in a curve from one end of the second to the other, and the intervening integument is dissected away. The margins of the gap are drawn together with fine sutures, and the bridge of tissue containing the hair follicles is thus shifted away from the cornea. The second incision should go down to the tarsal cartilage, but should not cut through it. In dissecting away the flap of integument, the fibres of the orbicularis should not be disturbed. If the flaps, after completion of the operation, look blue, and danger of sloughing is apprehended, the parts should be dressed with frequently changed compresses soaked in hot bichloride solution (1-8000); otherwise an ordinary antiseptic dressing may be applied. The stitches should be removed at the end of the third day, when union is usually complete.

Fig. 170



Jaesche-Arlt operation for trichiasis. *a*, incision along the intermarginal portion of lid; *b*, position of the second, and *c*, of the third incision.

Double transplantation operations have been proposed and practised by a number of surgeons, support being given to the cilia by transplanting a strip of skin to the intermarginal space. The fine cutaneous hairs in the transplanted flap often irritate the cornea and thus vitiate the value of some of these operations. In order to obviate this difficulty Van Millingen proposed his *tarso-cheiloplastic operation*, which is done as follows:—

The intermarginal space is split from end to end as in Arlt's operation and sufficiently to produce a gap 3 mm. in breadth at the central part of the lid, and gradually becoming narrower toward the canthi. The gap is kept open by sutures passed through the folds of skin on the upper lid, and by means of these the lid is prevented from closing for twenty-four hours at least. As soon as the bleeding has ceased, a strip of mucous membrane of the same length as that of the lid and 2 or $2\frac{1}{2}$ mm. in breadth is cut out with two or three clips of a curved pair of scissors from the inner surface of the under lip, and placed at once in the gap at the intermarginal space. It should then be pressed into position with a pledget of cotton wool steeped in sublimate solution.

Sutures are altogether superfluous and do more harm than good. The operated lid is then covered with a flap of linen containing a thick layer of iodoform and vaseline and this is covered over with cotton wool. Both eyes should be bandaged. The bandage ought to be removed once in twenty-four hours and the sutures on the upper lid ought not to be removed before the second day.

Operations for Entropion.—Several methods of correcting spasmodic entropion have been referred to on page 209. In the *spasmodic entropion* of elderly people the following operation may be done :—

With entropion forceps a strip of skin of suitable width, parallel to the ciliary border of the lid, is pinched up and excised, together

Fig. 171.



Cross-bar entropion forceps.

with the subjacent fibres of the orbicularis muscle. The wound is then closed with silk sutures and dressed in the ordinary way. The sutures are removed on the third day.

Instead of excising a horizontal fold of skin, excision of a triangular portion may be performed (Von Graefe). The base of the triangle is placed 3 mm. from the ciliary margin and the width and length are made according to the looseness of the tissues. After the flap is excised the margins are freed and brought together with sutures, but no sutures are applied to the horizontal incision. If necessary, the subjacent tarsal cartilage may be removed.

In organic entropion an operation must be made which will not merely evert the misplaced border, but also alter the curve of the tarsal cartilage, which usually has become thickened. Two operations will be described :—

Green's Operation.—This operation is especially designed for cases of cicatricial entropion of the upper eyelid following trachoma, in which, by cicatricial contraction, the tarsus has become incurved and the whole lid margin appears narrowed. The operation is thus described by its originator :—

An incision is made in a line parallel to and about 2 mm. distant from the row of openings of the ducts of the Meibomian glands, is car-

ried through the entire thickness of the tarsus, and should extend in cases of complete entropion from near the inner to the outer canthus. The lid is everted and held securely by the fingers and no instruments applied to hold the eyelid while the incision is being made. A strip of skin is now excised, which should not exceed 1½ or 2 mm. in width, and should taper to a point at each end. Its lower boundary should be about 1½ mm. above the line of the eyelashes. Only the skin and adherent connective tissue should be removed, leaving the orbicularis fascia and muscle intact. Curved needles threaded with fine silk are used in passing the sutures. The needle is first introduced a little to the conjunctival side of the row of eyelashes, and is brought out just within the wound made by the excision of the strip of skin. It is then drawn through, inserted again in the wound near its upper margin and passed deeply backward and upward, so as to graze the front of the tarsus and emerge through the skin of the eyelid a centimetre or more above its point of entrance. On tying the two ends of the thread together the skin wound is closed and the loosened lid margin is at the same time everted and brought into a correct position. Three sutures generally suffice for the accurate adjustment of the lid margin. In the spaces between and beyond the sutures the eyelashes may be turned upward against the front of the eyelid, and fixed there by means of collodion. The stitches should be removed at the latest the day after the operation, reinforcing the line of suture by means of collodion. The skin wound heals in from two to five days. The incision in the tarsus upon the conjunctival aspect of the lid heals by granulations and requires several weeks.

Hotz's Operation.—This operation, as now practised by its author, is described in his own words,[1] as follows:—

"A transverse incision from canthus to canthus is made through skin and subjacent tissues, but instead of being made near and parallel with the free border (as in the former methods), the incision in this operation is to follow the *upper* border of the tarsus. It therefore describes a slight curve beginning and ending at a point about 2 mm. above the canthus, but being 6 to 8 mm. distant from the free border in the centre of the lid. While an assistant is holding the edges of the wound well separated, the surgeon lifts up with forceps and excises with scissors a narrow bundle of the muscular fibres which run transversely along the upper border of the tarsus. Now the sutures, which are to include nothing but the cutaneous wound borders and the upper border of the tarsus, are inserted. The first suture is placed in the centre of the lid; the curved needle, armed with fine, black aseptic silk, is passed through the lower wound border, there taken again in the needle-

[1] Dr. Hotz kindly furnished this description.

holder, it is boldly thrust through the upper border of the tarsus and returned through the tarso-orbital fascia just above this border; and finally it is carried through the upper wound border. One similar suture is placed at each side of the central one, and these three stitches are usually sufficient for our purpose, to wit to draw the skin of the eyelid up toward the upper border of the tarsus and establish a firm union between these parts. This artificial union produces a slight tension of the tarsal skin, which, however, is sufficient to relieve any ordinary degree of entropion. But when the lids have been badly contracted—when the palpebral aperture has become unnaturally narrow, or the free border of the lid has become entirely merged into the plane of the conjunctiva—these complicated cases require, in addition to the above operation, such surgical measures as canthotomy; the restoration of the free border either by grooving the tarsus (see my paper in Trans. of IX. International Med. Congress), or by grafting."

The constant association of trichiasis and entropion makes their surgical treatment in many particulars identical.

Operations for Ectropion.—If the ectropion is associated with relaxation of the tissues, as is often seen in old people, excision of a V-shaped piece of the whole thickness of the lid may be practised. This may be understood by a reference to the figures. (Figs. 172 and 173.)

Fig. 172.

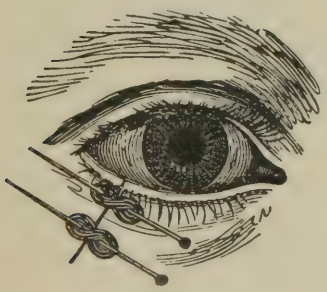
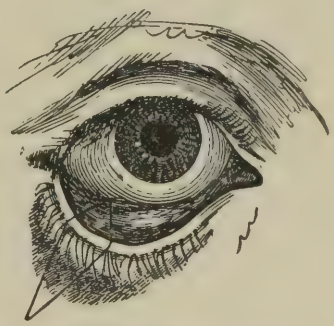


Fig. 173.



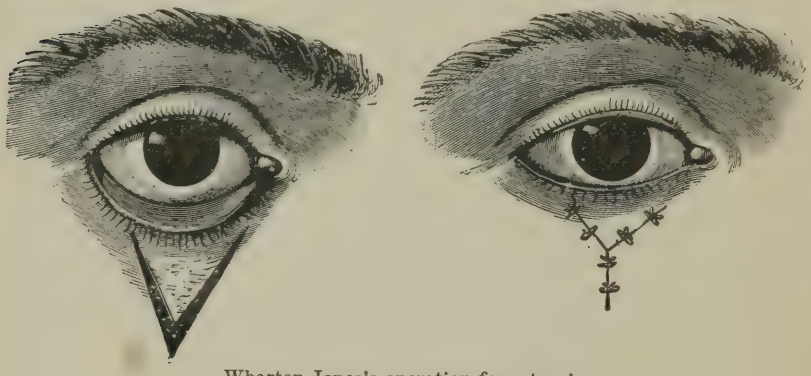
Adams's operation for ectropion by excision of a V-shaped piece of the lid (Lawson).

Another useful procedure is the operation of Snellen, by which the everted mucous membrane is returned into place by a suture entered at two points, one-third of an inch apart, passed deeply,

and brought out upon the cheek where the ends are tied over a piece of drainage tube.

Ectropion from the contraction of cicatrices, abscesses, etc., usually requires a plastic operation (*blepharoplasty*) in which the vicious cicatrix is embraced in an incision. If the scar is small it may be done in the manner indicated in the figures, which is known as Wharton Jones's operation.

Fig. 174. Fig. 175.



Wharton Jones's operation for ectropion.

A horn spatula is put into position to protect the eye and a V-shaped incision is made. The flap is then separated sufficiently to enable the lid to be pushed up into place. The lower part of the wound is drawn together with sutures, thus converting the V into a Y. If possible the triangular flaps must include the cicatrix which has produced the original trouble.

If the cicatrix is extensive the operation consists in dissecting out the scar, and filling the gap by transplanting a flap of skin from the forehead or from the nose or cheek. Many operations of this kind have been devised; the site and character of the lesion will in each instance determine the best method of procedure, and it would not be possible in a chapter of the present scope to indicate the numerous ingenious methods which have been devised for the correction of cicatricial ectropion by these blepharoplastic procedures, or for the formation of an entirely new lid to replace one that has been eaten away by some disease such as lupus.

Many disadvantages are associated with blepharoplastic operations, not the least being the extensive scar resulting at the spot of removal of the flap which is utilized. To obviate these a plan originally introduced by Lefort and Wolfe has been practised by many surgeons with success. This consists in transplanting skin without a pedicle from a distant part. The flap must be about one-third larger than the spot which it is intended to cover to compensate for subsequent shrinking. It should be shaved down so as to be as free as possible from subcutaneous connective tissue and fat. Thiersch's method is also warmly advocated.

Operations on the Conjunctiva.

Operations for Pterygium :—

(a) *Excision.*—The pterygium is seized with toothed forceps, raised from the surface of the eye, and shaved off with a Beer's knife from its corneal attachment. It is then turned backwards, carefully dissected from its base, and excised. This leaves a gaping wound in the conjunctiva which is then drawn together with several points of sutures. Complete excision is not applicable to large and fleshy pterygia.

(b) *Transplantation.*—This consists in dividing the corneal attachment, turning the pterygium back, fixing its free extremity in an incision in the lower part of the conjunctiva by means of a fine suture, or the growth may be split and each half transplanted above and below.

Some surgeons remove the growth by *strangulating* it with a ligature threaded in two needles and introduced beneath the growth, a method which does not compare favorably with either excision or transplantation.

After the apex of the pterygium has been separated from the cornea, the vascular subconjunctival tissue must be scraped away down to the sclera ; otherwise there will be reattachment. The suggestion of Prince to tear loose the pterygium with a strabismus hook instead of separating the point with a knife is a very good one.

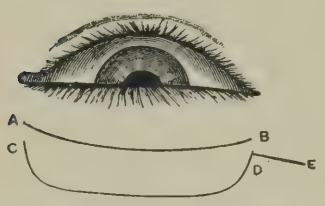
Operations for Symblepharon.—An attempt may be made to remedy this condition by dividing the adhesion and uniting the cut edges of the conjunctiva with sutures, or covering the raw surface left after severing the adhesions with flaps of healthy conjunctiva taken from the unaffected parts of the eyeball, or by dissecting back the symblepharon as far as the retrotarsal fold, doubling it upon itself so as to oppose a mucous surface to

the globe, and fixing it in this position by means of a ligature which is armed by two needles and passed through the lid from the conjunctiva outwards.

A recently suggested operation is one by Harlan (Harlan's operation). This is applicable to cases where the whole lid is firmly and closely adherent to the ball, and is thus described by its author :—

The adhesion is freely dissected until the upward movement of the ball is entirely unimpaired and an external incision, represented at *A B* in the accompanying cut, along the margin of the orbit, is carried through the whole thickness of the lid, which is thus separated from its connections except at the extremity. A thin flap, *C D*, is then formed from the skin below the lid, care being taken to leave it attached at its base line by the tissue just beneath *A B*, as well as at the extremities. On this attachment it is turned upward as on a hinge, bringing its raw surface into contact with the inner surface of the lid, and its sound surface presenting toward the ball, and held in this position by suturing its edge to the margin of the lid. In dissecting up the flap, the incisions are carried more deeply into the orbicularis muscle, when the base line *A B* is nearly reached, to enable it to turn more readily. The bare space left by the removal of the strip of skin is nearly covered without strain by making a small horizontal incision, *D E*, at its outer extremity and forming a sliding flap.

Fig. 176.



Lines of incision in Harlan's operation for symblepharon.

Transplantation of the Rabbit's Conjunctiva.—In cases of extensive adhesion between the ball and the lids, such, for instance, as may be remedied by Dr. Harlan's operation, the transplantation of rabbit's conjunctiva has been attempted.

In this operation, after the adhesions have been severed, the raw surfaces are covered by a flap of conjunctiva taken from a rabbit's eye, so removed as to be free from all submucous tissue and somewhat larger than the defect which it is expected to cover. It is better to insert the sutures, with which it is afterwards put in place, before its removal, as this then marks out the position of the flap and at the same time gives a means by which it may be transferred from the eye of the rabbit to the

eye of the patient. It must be kept warm and moist during the process of transferring it. Instead of utilizing the conjunctiva from a rabbit's eye, mucous membrane may be taken from the lip of the patient. All bleeding from the flaps must be stopped before the attachment is made.

Operations on the Cornea.

Paracentesis Corneæ.—The local application of cocaine is generally sufficient, but in nervous subjects and young children general anæsthesia may be necessary. The operation is performed as follows :—

The cornea is punctured near its lower margin, or in the case of an ulcer, through its floor, with a paracentesis needle constructed with

Fig. 177.



Paracentesis needle.

a shoulder to prevent an undue depth of entrance, and inserted at an angle of 45° with the point of contact ; or with a broad needle held flatwise, the point being kept well forward so as to avoid wounding the lens. By rotating the needle slightly on its long axis, the lips of the opening are separated and the contents of the aqueous chamber more readily escape. The act of withdrawing the needle must be slowly done lest a sudden gush of aqueous cause prolapse of the iris. The eyeball may be steadied with an ophthalmostat (see Fig. 178) or fixation forceps (see Fig. 179), provided the former does not put too much pressure on the globe, or the lids may be separated by the surgeon's fingers. If it is necessary to reopen the wound, the probe end of the instrument should be used.

Application of the Actual Cautery.—The indications for this application in corneal disease are given on page 272. If possible, a suitable galvano-cautery should be employed. If this is not at hand, a platinum probe held by a handle similar to the one which is attached to a laryngoscope mirror will suffice. It is done as follows :—

According to the situation of the ulcer, and according to the condition of the iris, the eye either is atropinized or eserinized, a few drops

of cocaine solution are instilled to produce anæsthesia, and the probe or the point of the cautery is brought to a red-heat, transferred to the point of disease, and all of the sloughing material, and particularly the edge of the ulcer, is gently but thoroughly cauterized. It is not necessary to burn beyond the edge of the ulcer into sound tissue. The exact extent of the ulcerated area, even to the finest spot characterized by loss of epithelium, may be ascertained by the use of fluorescin, as has been suggested by Nieden. This will prevent the necessity of a second application. The separation of the lids with a stop-speculum is needless; in fact, this is disadvantageous on account of the pressure it exerts upon the eyeball. They may be parted by the hands of the operator himself. After the operation the eye may be washed out with boric acid solution, a drop of atropine instilled, and a bandage applied.

Operation of Saemisch: Saemisch's Section.—The upper lid being raised on an elevator by an assistant, the surgeon proceeds as follows:—

The conjunctiva below the cornea is seized with fixation forceps, a cataract knife is entered on one side of the cornea with its cutting edge upward, carried across the anterior chamber to the other side of the ulcer, and the section made directly through the diseased area, evacuating the collection of pus in the layers of the cornea and at the bottom of the anterior chamber. If the hypopyon is tenacious, this may be removed by inserting a delicate pair of forceps through the incision and seizing the slough, or it may be washed out with a specially devised syringe. If the pus re-accumulates, the wound should be reopened with a probe and the contents of the anterior chamber again evacuated.

A great objection to this operation is the danger of prolapse of the iris.

Operations for Staphyloma.—If the measures used to prevent the formation of staphyloma have been unsuccessful (pages 271 and 279), an operation must be done for its relief. In partial staphylomas, vision may sometimes be improved by iridectomy, and even by a double excision of the iris, but very often these measures fail, and then its removal may be necessary.

De Wecker's Method.—This is suited to complete staphyloma limited to the cornea, and is thus described by the author:—

Four sutures should be inserted in the conjunctiva after it has first been carefully detached from the corneal margin almost as far as the equator of the eye. In order to avoid confusion at the moment of

tightening the threads, the precaution should be taken of having them of different colors. The removal of the staphyloma is performed by transfixing it through the middle and cutting outwards, then seizing the end of the flap thus formed and removing the rest with scissors. Care must be taken that the lens escapes from the eye. When this is ascertained, the sutures in the conjunctiva are tightened and the conjunctiva drawn over the wound. If good preservation of form is obtained, a subsequent tattooing of the conjunctiva may make the use of an artificial eye unnecessary.

In most instances of complete staphyloma, with participation of the sclerotic, the best operation is evisceration or enucleation.

Tattooing the Cornea.—In order to conceal the disfigurement of a dense leucoma, it has been suggested to tattoo the white tissue. This is done as follows :—

The eye being steadied by the fingers, a number of fine needles fixed at exactly the same level are prepared, and India ink rubbed into a fine paste is placed close at hand. The cornea now being rendered anæsthetic with cocaine, the operator applies the ink to the surface and pricks this into place by means of the needles. Sometimes the entire surface can be blackened at one sitting ; sometimes several operations are necessary. The excess of pigment can be flooded away with a saturated solution of boracic acid. It has been suggested by some surgeons to use variously-colored pigments in order to attempt to reproduce the colors of the iris.

The principal operations for *conical cornea*, the method of *removing a foreign body* imbedded in the cornea, and the manipulations necessary for closing *scleral wounds*, have been described (see pages 294, 295, 305).

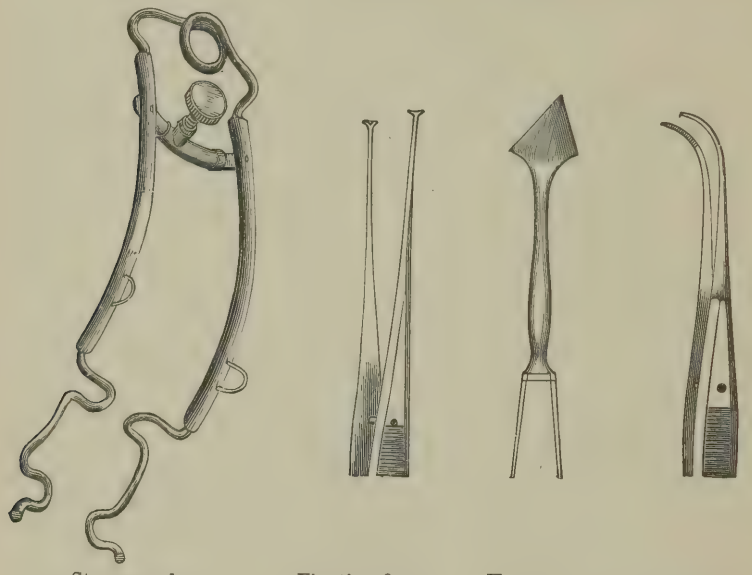
Operations upon the Iris.

Iridectomy.—The following instruments are necessary : Stop speculum, fixation forceps, bent keratome, iris forceps, blunt hook, iris scissors, and horn spatula (Figs. 178, 179, 180, 181, 182, 183, 184). The operation is thus performed :—

The patient being placed in a recumbent position and the eye being under the influence of cocaine, the surgeon separates the lids by means of an ophthalmostat, fixes the eye by seizing with forceps the conjunctiva and subconjunctival tissue at a point directly opposite to that of the proposed section, and introduces the lance-shaped keratome in the

following manner: The point of the knife is brought into contact with the apparent corneo-scleral margin, or, in some instances, about a millimetre from the junction of the sclera with the cornea, and in a direction at right angles to the cornea, which direction it keeps until the

Fig. 178. Fig. 179. Fig. 180. Fig. 181.



Stop speculum. Fixation forceps. Keratome. Iris forceps.

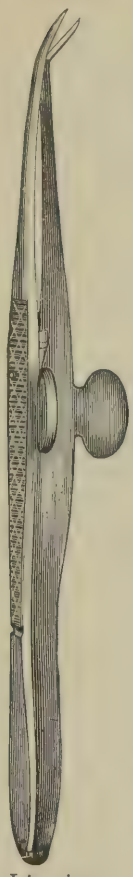
point just penetrates into the anterior chamber. The handle is then well depressed so that the point of the knife shall not wound the iris or lens, while the blade is slowly thrust onwards until the section is of the desired extent. (Fig. 185.) The knife is then slowly and cautiously withdrawn, keeping its point well forward toward the posterior surface of the cornea, so as to allow a slow escape of the aqueous humor and to avoid scratching the capsule of the lens.

The *first stage* being completed, the fixation forceps is handed to an assistant who rotates the globe a little downwards, if the section has been made upwards, and the surgeon introduces curved the iris forceps, expanding the blades so as to grasp the pupillary margin, cautiously withdrawing the forceps with the included portion of the iris, and snipping off the latter close to the wound by one or two cuts with a delicate pair of curved scissors. (Fig. 186.) If the anterior chamber is very shallow it is safer to substitute for the lance-shaped instrument a Graefe cataract knife, making a puncture and counter-puncture and then cutting outward. Some operators prefer this method under all circumstances.

Fig. 182. Fig. 183.

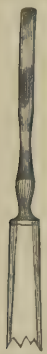


Blunt hook.



Iris scissors.

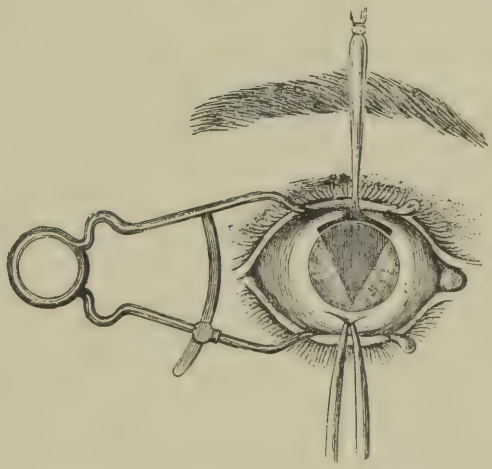
Fig. 184.



Tortoise shell spatula.

If the section of the iris should cause hemorrhage into the anterior chamber, an attempt may be made to remove the blood by separating the lips of the wound with the horn spatula and making very cautious pressure on the cornea,

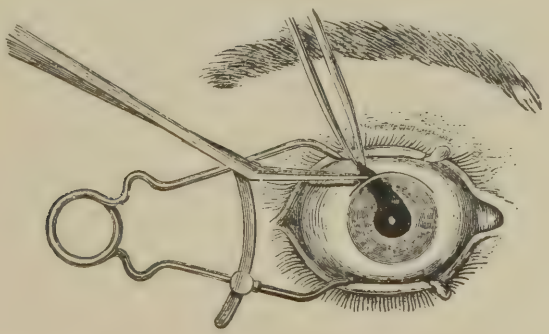
Fig. 185.



Operation of iridectomy. Keratome within the anterior chamber (Juler).

but triturating movements carried on to any extent are done at the risk of bruising the lens and causing subsequent cataract. The conjunctival cul-de-sac is disinfected with a *weak* bichloride solution, and the length of the wound, and especially its angles, are inspected to see that

Fig. 186.



Operation of iridectomy. Excision of the piece of iris (Juler).

the iris is not entangled. Should there be any entanglement of the iris, an endeavor should be made to disengage this with the point of a horn spatula. If the wound appears clear the eye is bandaged with an antiseptic roller placed over a wad of soft sterilized cotton. One or both eyes may be bandaged. The author prefers to bandage both of them for the first twenty-four hours. Usually the healing is kind, the anterior chamber is quickly restored, and the bandage may be removed at the end of forty-eight hours, and the patient directed to wear a shade or dark glass.

This, in general terms, describes the method of performing an iridectomy, which, however, may require certain modifications according to the indications and according to the judgment of the operator.

(1) *Position of the Operator.*—The operator may stand behind the patient's head and push the knife from him if he is making an upward section, or he may stand in front of the patient and push the knife towards him in a similarly made section. The latter procedure is better if the anterior chamber is shallow, as the operator can more readily watch the point of the knife. This direction refers to the lance-shaped keratome.

(2) *Point of Entrance of the Keratome.*—This depends upon whether the iridectomy is for optical purposes or for the relief of intraocular tension. If for the former, its position should be exactly at the apparent corneo-scleral border; if for the latter, further back, about a millimetre from this position, passing through the sclera.

(3) *Position of the Iridectomy.*—If the iridectomy is for optical purposes, the point of selection is governed by the condition of the cornea. The best position for an artificial pupil is inward or inward and downward, other things being equal.

If the operation is to restore a pupil to an iris which has been bound down by extensive synechiæ, that portion of the iris is excised which is least attached. Generally it is best to perform the section upward and make a broad iridectomy. The same is true if the operation is performed for a partial cataract, although its exact position must be governed by the condition of the lens.

(4) *The Width and Depth of the Coloboma.*—A glance at the accompanying figures explains the three forms of iridectomy,

namely, a broad peripheral iridectomy, as in glaucoma; a small iridectomy, with preservation of the ciliary border, and a narrow iridectomy, for instance for optical purposes.

Fig. 187. Fig. 188. Fig. 189.



Fig. 186. Broad peripheral iridectomy. Fig. 187. Small iridectomy, with ciliary border preserved. Fig. 188. Narrow iridectomy for optical purposes (Swanzy).

Iridotomy (*Irotomy*).—This operation, which is designed to manufacture an artificial pupil, is commonly selected for cases in which the lens is absent, as after cataract extraction, and in which the pupil has become entirely occluded on account of iritis. It may be performed by simply splitting the fibres of the iris with a broad needle, the retraction usually affording a sufficient pupil; or a blunt hook (see Fig. 182) may be introduced and the operation converted into a small iridectomy; or a triangular shaped piece of the iris may be excised with delicate scissors introduced through a corneal wound. Ordinarily the method of De Wecker is the one which gives the most satisfactory results. This is performed as follows:—

A small triangular keratome, preferably fitted with a shoulder, is entered into the apparent corneo-scleral margin and pushed on until an incision of about 5 mm. is made. It is then slightly withdrawn and again reinserted, this time causing the point to pierce the iris or the membrane which it is desired to divide. The instrument is now withdrawn and the delicate forceps-scissors of De Wecker are introduced as follows: The instrument is inserted flat-wise with closed blades through the wound. One blade is now made to pass through the opening in the iris and the other in front of the iris. The blades are now pushed down as far as it is needed to go, closed after the manner of a pair of scissors and withdrawn. The cut thus made across the line in which there is the greatest tension, retraction takes place, and if the operation has had a favorable result a fair pupil results. Not uncommonly vitreous is lost during the operation.

OPERATIONS UPON THE SCLERA.

Sclerotomy.—This is an operation which is practised for the relief of glaucoma, and in the hands of some surgeons is made to substitute the operation of iridectomy. It is performed as follows:—

A narrow Graefe's cataract knife is passed through the sclerotic 1 mm. from the margin of the clear cornea in front of the iris and brought out at a corresponding point on the other side, so as to include nearly one-third of the circumference. The puncture and counter-puncture are then enlarged, but the central quarter of the sclerotic flap, and as much of the conjunctiva as possible, except where punctured, are left undivided. The incision should be made with a slight sawing movement. The knife must be withdrawn very carefully in order to prevent prolapse of the iris. If this occurs, replacement should be attempted with a horn spatula. In the event of failure the prolapsed iris must be excised and the sclerotomy is converted into an iridectomy. Preceding the operation, eserine should be used to contract the pupil, and this drug must be continued during the process of healing.

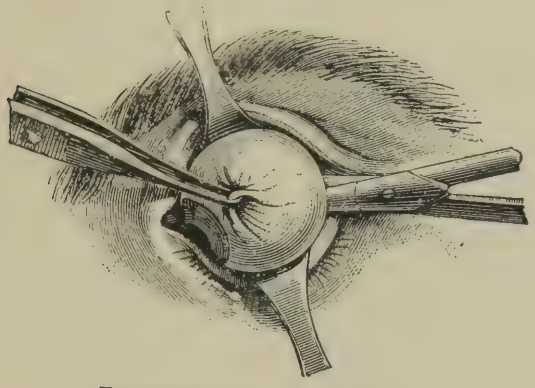
Enucleation of the Eyeball.—The following instruments are necessary: A stop speculum, fixation forceps, dissecting forceps, strabismus hook, and a pair of scissors curved on the flat (enucleation scissors).

The patient being fully etherized, the lids are held apart with a stop speculum while the surgeon divides the conjunctiva and adjacent fascia with scissors, in a circle as close as possible to the margin of the cornea. This is sometimes called "circumcising the cornea." The tendons of the ocular muscles, beginning with the inferior rectus, are then successively raised upon a strabismus hook and divided, care being taken when the tendon of the external rectus is reached, to leave a small stump which may be utilized afterwards as a point of application for the forceps. The eye being made to start forward by inserting the stop speculum somewhat more deeply, the stump of the tendon previously mentioned is seized, the eye is drawn forward, the face of the patient being turned toward the operator, and the curved scissors are introduced between the severed conjunctiva and the freed eyeball, and made to follow the curve of the latter until the optic nerve is reached, when the blades are expanded, and the nerve seized and cut squarely off. The attachments of the oblique muscles and the remaining tissue which may cling to the eyeball are then severed. (Fig. 190.)

Hemorrhage is usually not severe, and is readily controlled by pres-

sure. After freely irrigating the socket with a bichloride solution, it should be dusted with iodoform or aristol and a full antiseptic dressing applied. Some surgeons recommend the introduction of a few points

Fig. 190



Enucleation of an eyeball (Meyer).

of interrupted suture to close the conjunctival wound. This usually is not necessary. A drainage tube may be placed at the outer canthus before the application of the bandage.

The operation just described is sometimes known as Bonnet's method. The eye may also be removed by what is known as the Vienna method, as follows:—

The only instruments necessary are a pair of strong scissors and toothed forceps. The tendon of the internal rectus, together with the overlying conjunctiva, is seized in one grasp with the forceps. It is then divided and the stump retained in the grasp of the instrument. With the scissors the inferior rectus and superior rectus are now divided, together with the overlying conjunctiva. The globe is drawn forwards, rotated outwards, and the optic nerve divided. The operation is concluded by cutting the external rectus and the two oblique muscles close to the globe. This operation can be rapidly performed. It, however, does not always yield as good a stump as the more slowly performed procedure previously described.

Accidents.—(a) *Hemorrhage.*—Occasionally severe hemorrhage occurs during the enucleation of an eyeball, sometimes caused by an anomalous distribution of the vessels. If necessary, the orbit can be packed with antiseptic gauze. Sometimes the tissues of

the orbit will become very much infiltrated with blood and puff out in an alarming manner. The blood-clot, however, will gradually absorb, and usually no harm results.

(b) *Perforation of the Sclera.*—Sometimes, especially in a ball having very thin walls, the sclera is punctured in the endeavor to cut the optic nerve. This simply complicates the operation, because it is more difficult to remove a collapsed ball than one which is distended. Should the operator be so unfortunate as to cut through the sclera and leave a portion of it remaining behind, he must proceed to search for the fragment, which can be picked up with forceps, and cut it off together with the nerve.

(c) *Consecutive or Secondary Hemorrhage.*—Occasionally a consecutive or secondary hemorrhage occurs after enucleation. The bandages should be removed, the lids separated, the blood clot removed, the orbit irrigated with an antiseptic fluid, and, if pressure fails to stop the hemorrhage, a packing of antiseptic gauze should be inserted.

The *after treatment* of an enucleation consists in placing the patient in bed, certainly for the first few days. He should have low diet. No severe pain ought to follow an enucleation, and decided headache, elevation of temperature, and restlessness may lead to the suspicion of meningeal complication. In a certain number of instances meningitis has followed the operation, especially when it has been performed on an eye within which suppuration is taking place. Under modern methods of operating and with antiseptic precautions, this accident is fortunately a rare one.

Insertion of Artificial Eyes.—An artificial eye may be inserted as early as the second week after an enucleation of the eye (some operators insert it at a much earlier date), provided there has been kind healing of the stump, but it is better to wait at least a month. The tissues have then become firmly healed and are able to bear the shell. For the first week or two the artificial eye should be smaller than that which is a perfect match for the opposite side. The eye may then be exchanged for one which in size is as nearly as possible a match for the fellow eye. At first the eye may be worn for several hours at a time. Soon it can be worn all day, but it never should be allowed to remain in the socket during the night. The wearer

of an artificial eye must be cautious that the enamel is always smooth. It is not necessary to keep an artificial eye in water during the night. It should be washed with a little alcohol and water, and allowed to dry.

In order to insert an artificial eye, the upper eyelid is seized between the fingers of the left hand and drawn gently down and out, and the larger end of the shell is inserted vertically beneath it, then brought to a horizontal direction, while at the same time the lower lid is pulled down, when the shell slips into place. In order to remove an artificial eye, the head of a large pin is inserted beneath its lower margin, the lower lid being at the same time depressed, while the eye is tipped upward and forward, when the pressure of the upper lid will force it out. Very soon patients become exceedingly expert in taking out and introducing artificial eyes, and do not require the aid of a pin in making the manipulation just described.

Instead of the operation of enucleation, certain substitutes have been proposed, the most important of which are :—

(1) *Evisceration or Exenteration.*—This consists in an evacuation of the contents of the eye within the sclerotic, and the closure of the sclero-conjunctival wound with sutures, thus forming a movable stump for the artificial eye.

The instruments required for the operation are a speculum, fixation forceps, a narrow knife, a pair of scissors and an evisceration spoon. It is performed as follows :—

The speculum being introduced, the conjunctiva is loosened around the cornea ; the anterior chamber is transfixed with the knife on a level with the horizontal meridian, the lower portion of the cornea separated, the flap seized with forceps, and the remainder of the cornea cut away at the corneo-scleral margin. With the evisceration scoop the contents of the globe are thoroughly evacuated, care being taken that nothing is left behind, especially none of the choroidal tissue. The cavity of the globe is thoroughly wiped out with sterilized cotton wool and all bleeding is stopped. The edges of the conjunctiva are united by means of a suture similar to the string which draws shut a tobacco pouch, a suture sometimes called the "*tobacco-pouch suture.*" This should include the conjunctiva alone unless this is very much macerated, when it may be necessary to include the sclera.

Considerable pain follows the operation, together with œdema and swelling of the surrounding tissues. In order to avoid this,

it has been recommended to introduce a horse-hair drain, and Prince has suggested wiping out the cavity with carbolic acid in order to allay the pain.

Mules has further modified the method by inserting into the scleral cavity a hollow glass ball, pressed down with a special instrument designed for the purpose, then carefully stitching the split sclerotic over the ball and sewing the conjunctiva separately.

Frost and Lang have proposed the introduction of Mules's sphere in Tenon's capsule after ordinary enucleation, closing the muscles and conjunctiva over it in the usual way.

(2) *Resection of the optic nerve* is performed as follows:—

A vertical incision is made over the insertion of the external rectus muscle, and the conjunctiva separated as far back as possible with complete exposure of the muscle which is secured by sutures near its insertion. The muscle is then cut on the temporal side and all the tissues separated from the eyeball. The optic nerve is brought forward with a hook, the tissues of the orbit being pressed aside by means of a retractor. A second hook is inserted underneath the optic nerve and pressed backward, exposing a portion of the nerve, which is then firmly grasped in flat forceps, so as to prevent hemorrhage. The eyeball is rotated forward, and a small piece near its entrance into the ball cut off. Pressure is continued for a few moments, the forceps removed, the eyeball rotated into place, and the external muscle reunited by means of the sutures. Careful antiphlogistic dressings applied constantly are said to prevent the danger of severe reaction.

This operation has been urged by De Wecker and others, and is said to be a safe procedure. It may be done when some of the strong indications for enucleation or evisceration are not present.

Extirpation of the Whole Contents of the Orbit.—This is the operation necessary in certain cases of malignant disease.

It is performed by dividing the external commissure of the lids, incising the conjunctiva, severing the levator palpebræ, attachments of the oblique muscles, and all other orbital connections of the eye, and then, drawing the globe forward, the optic nerve is cut with curved scissors, introduced on the outer side. The lachrymal gland should also be removed, if it is diseased.

Operations for Cataract.

The following methods constitute the most important varieties of operation which have been and are practised for the cure of cataract: The flap operation; the linear extraction; the modified or peripheral linear (Von Graefe); the short flap (De Wecker); the needle operation (or that of solution); and the suction method. The old operation of *reclination*, *depressing*, or *couching*, as it has variously been called, by which the lens was forcibly thrust down into the vitreous, is no longer practised.

1. *Needle Operation* (*Discission—Operation for Solution*).—By this operation the capsule of the lens is opened, the aqueous humor admitted to the lens matter, and absorption thus produced. It is applicable to the treatment of juvenile cataracts, and is rarely employed after the fifteenth year.

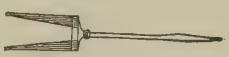
The instruments required are two cataract needles (lance-headed or knife-needle, according to the fancy of the operator), a stop speculum, and fixation forceps.

Fig. 191.



Bowman's stop needle.

Fig. 192.



Knife-needle.

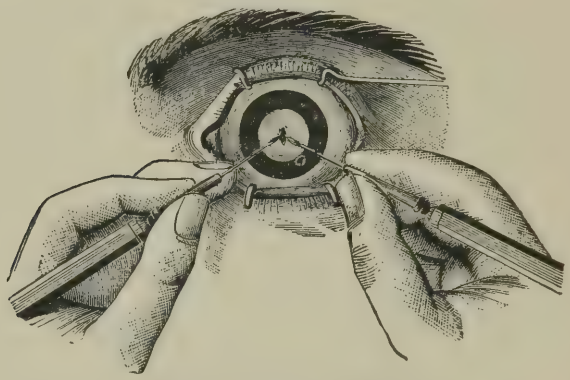
After the induction of general anæsthesia in young children, or the use of cocaine in older subjects, and full dilatation of the pupil, the operation is thus performed:—

The lids being separated by the stop speculum, the surgeon fixes the eye with forceps, and enters the cataract needle through the cornea at its outer side and carries it across to the centre of the pupil, when the point is turned to the lens, the shaft caused to enter the cornea a little more deeply, and a laceration made in the capsule by depressing the handle of the instrument with a lever-like movement. Two cuts are made at right angles with each other, and the lens matter may then be slightly broken up with the point of the needle. Care must be taken not to use so much force as to dislocate the lens and not to lacerate too freely in the first operation, lest the lens substance, swelling up from contact with the aqueous humor, should produce injurious pressure on the iris and ciliary body. The operation usually has to be repeated at intervals, the second operation being done after the swollen

lens matter caused by the first incision has disappeared by absorption and the eye has become perfectly quiet.

At the second operation the needle may be used more freely, or two needles may be used in the manner shown in the figure. (Fig. 193.)

Fig. 193.



Discission with two needles.

The points enter the lens substance and the handles are approximated, thus making a decided separation in the remaining opaque matter. The use of two needles is applicable to cases where not much lens tissue remains. In order to prevent too deep entrance of the needle, it is sometimes constructed with a shoulder (stop-needle—see Fig. 190).

After-treatment.—The conjunctival sac should be irrigated with bichloride solution (1–8000), atropine freely instilled, and pupillary dilatation maintained during the entire treatment. The patient should be put to bed, the room darkened, and cold compresses may be applied for the first twenty-four hours. If at the end of this time there is no decided reaction, the cold compresses may be discontinued, but not the atropine.

Decided reaction, with hyperæmia of the iris, pain, and ciliary congestion, call for the increased application of atropine, and, if the age of the patient permits it, the use of leeches to the temple. Great swelling of the lens matter, in addition to the symptoms of iritis, may give rise to a glaucomatous state. Then the lens matter which has escaped into the anterior chamber must be evacuated by a *linear extraction*, or, what is prac-

tically the same thing, by a free paracentesis of the cornea. The *suction method* may also be employed under these circumstances. Some operators invariably extract the lens a few days after needling, a practice which certainly hastens the restoration of vision, but which is not so safe as repeated discissions. The student should remember that even in the hands of the most skilful surgeons the operation of needling a cataract is surrounded with dangers, and sometimes has resulted in a general inflammation of the globe and loss of the eye—dangers which are lessened by strict antisepsis, proper laceration of the capsule, and care not to undertake too much at the first operation.

2. *The Suction Method.*—This operation is specially adapted to cases of completely soft or fluid cataracts, and is also used, as has been stated, to remove lens matter which has been broken up by discission. It is done as follows:—

The pupil being dilated with atropine, the anterior capsule of the lens is freely lacerated with two needles. A small corneal wound is made with a keratome passed obliquely through this membrane between its centre and periphery. Through this opening and into the lens matter, the "suction curette" is passed. This consists of a curette roofed in to within two millimetres of its extremity, with a handle and a piece of India rubber tubing furnished with a mouth-piece, which the operator applies to his lips and gently sucks out the lens matter into the syringe. This is Teale's method.

The same may be accomplished by using the syringe of Bowman, in which a sliding piston is worked by the hand. The point of the syringe must not penetrate too deeply, must be behind the lens-matter which is to be removed, and must not be pushed back of the iris.

The after-treatment consists of rest, bandage, and the local use of atropine.

3. *Linear Extraction.*—This operation is suitable for quite soft cataracts, or those with a very small nucleus, and may be employed to remove lens matter after discission. Although any lens, the substance of which is liquid enough to pass through a small corneal wound, may be removed by this method, it is better, if possible, to restrict the operation to cases of soft cataract occurring in patients under thirty years of age. (Noyes.)

The following instruments are necessary: A narrow keratome

or lance-shaped knife, fixation forceps, cystotome, curette, and stop speculum. The operation is as follows:—

The surgeon fixes the eye with forceps, after the introduction of the stop speculum, wide dilatation of the pupil having previously been obtained, introduces the keratome about one millimetre within the margin of the cornea, and makes a wound five millimetres wide. The instrument is now carefully withdrawn, with a slight lateral motion to make the wound a little larger, if necessary, and a sharp cystotome is introduced and the capsule of the lens is freely lacerated. The soft lens matter is now caused to extrude by counter-pressure on the cornea with a horn spud, the outer lip of the corneal wound at the same time being depressed with a curette. This is a *simple linear extraction.*

The same manipulations may be performed, assisted by an iridectomy after the corneal section, a small segment of the iris being withdrawn with either hook or forceps and excised. Instead of using the cystotome to open the capsule of the lens, some operators do this with the keratome after making the incision in the cornea, by causing the instrument to dip directly into the lens.

The after-treatment consists of bandage, atropine, and rest in a darkened room.

4. *Extraction of Hard Cataract.*—The essential characteristics of an operation for the removal of a hard cataract consist in making an incision within the cornea, at the corneo-scleral junction, or in the sclera, according to one or other of the methods in vogue, and the deliverance of the opaque lens through the wound thus made, after laceration of the capsule (by some surgeons in the capsule), sometimes with and sometimes without iridectomy. It would be impracticable to indicate the numerous modifications which have been employed in this operation, than which, as Dr. Noyes says, no surgical procedure has been more carefully studied and elaborated in every detail.

The following are some of the most important methods of operating:

Varieties of the Section.—(a) *Flap extraction.*—The incision is within and concentric with the margin of the cornea, and involves one-half of its circumference, being in a plane parallel to that of the iris. The section is either superior or inferior. No iridectomy is performed. At one time the knife usually employed was the instrument known as Beer's knife (Fig. 194).

(b) *Modified or Peripheral Linear Extraction* (Von Graefe's method).—The extreme periphery of the anterior chamber is opened by an incision ten millimetres long (originally it was smaller), through the sclerotic, one millimetre external to the

Fig. 194.



Beer's knife.

margin of the cornea, and two millimetres below the tangent of its summit. The point of the knife on entering the anterior chamber is directed, not to the point of counter-puncture, but toward the centre of the cornea. After the knife has entered fully 7 or 8 millimetres into the anterior chamber, its handle is depressed, counter-puncture is made at a point symmetrical to the point of puncture, the knife edge is directed obliquely forward, and the section completed by a gentle upward sawing movement. To cut the conjunctival tissue, the edge of the knife is directed forward, or a little upward if a conjunctival flap is desired. The knife almost universally employed is the narrow, straight-bladed instrument which is known as Graefe's cataract knife (Fig. 204). Iridectomy is performed.

This incision has undergone many modifications which chiefly consist in bringing the wound into a position closer to the corneal edge. Operators were induced to attempt various changes in the peripheral linear extraction owing to its dangers: hemorrhage from the conjunctiva; loss of vitreous, favored by the peripheral position of the wound; and cyclitis and consequently danger of sympathetic involvement of the other eye.

Short or Three Millimetre Flap Operation.—The knife is entered exactly at the corneo-scleral junction, at the outer extremity of a horizontal line which would pass three millimetres below the summit of the cornea. The flap embraces about one-fourth of the diameter of the cornea. The remaining steps are similar to the ones just described. No conjunctival flap is made. Iridectomy may or may not be performed. The Graefe knife is used.

This wound may not afford sufficient room for the expulsion

of a large cataract, and hence the incision may be made to include about two-fifths of the transparent edge of the cornea—a plan adopted by many surgeons.

Schweigger makes his incision below, at the inner border of the limbus, with a modified Beer's knife in such a manner that the flap has a height of four millimeters. The lens is expelled after capsulotomy, without iridectomy.

(d) *Corneal Incision.*—The incision in the form of a curved section is made through the lower portion of the cornea, the puncture and counter puncture being effected in the sclerotic. This is the method of Liebreich.

In another operation the corneal flap occupies the upper portion of the cornea, is 3 millimetres high, puncture and counter puncture being made 2 millimetres below the extremities of the transverse diameter of the cornea. This is the method of Lebrun.

Iridectomy is usually omitted. The knife may be the narrow, straight cataract knife. The chief objection to a corneal section is the formation of a scar to which the iris may become adherent.

By an examination of the accompanying diagrams the position of the incisions in the various methods just detailed may be understood.

Fig. 195.



Flap extraction.

Fig. 196.



Modified peripheral linear.

Fig. 197.



Short flap.

Fig. 198.



Corneal incision.

(e) *Extraction without Capsulotomy.*—Some surgeons, as a rule, deliver the lens without opening the capsule, and the operation is applicable to cases of over-ripe cataract and of high myopia with

vitreous changes. Pagenstecher, its chief advocate, makes his section in the lower half of the cornea by an incision placed in the sclerotic one millimetre from the corneal edge. Iridectomy is performed and the lens is delivered in its capsule, with a loop or specially devised curette. The chief danger of the operation is the risk of extensive loss of vitreous. The visual results are very good in successful cases.

Choice of an Operation.—In general terms, an incision passed exactly through the corneo-scleral junction or through the transparent margin of the cornea—forming, according to circumstances, a flap 3 to 4 millimetres in height, or, in other words, including one-quarter to one-third of the corneal periphery—will permit the-proper expulsion of the lens. (See also page 615.)

Preparation of the Patient.—This should include: A thorough examination of the physical condition of the patient; the removal of the conditions, already named, which contraindicate the operation; and the securing of surgically clean surroundings.

The following words, quoted from Knapp, forcibly present the necessary cautions preceding the operation: "Anything that produces a congestion, be it exposure to dust, lack of sleep, irritants such as corrosive sublimate or nitrate of silver in a strength to cause hyperæmia, lymphatic exudation, and exfoliation of epithelium, *i. e.*, food for bacteria, should be strictly kept off the eye for days previous to the operation. I like to have my patients one day or several days in the hospital, in good air, perfectly resting their eyes and bodies, doing nothing except washing their faces and eyes with soap two or three times daily. If, by this treatment, a congested conjunctiva has become pale and shining, I consider the patient in a fit condition for operation."

Position of the Patient.—The patient during the operation should lie, according to the fancy of the operator, upon an operating chair suitably inclined, or upon a bed. If the latter, the head should rest on a moderately hard cushion or pillow, another one at the same time supporting the shoulders, so that the position is as little strained as possible. The face must be turned so that a uniform light falls upon it.

Instruments, Solutions, and Dressings.—The instruments required are the following: A stop speculum (see Fig. 178), a

Fig. 199. Fig. 200. Fig. 201. Fig. 202. Fig. 203. Fig. 204.



Lid elevator.



Horn spoon.



Wire loop.



Cystotome.



Capsule forceps.



Cataract knife.

lid elevator, a horn spatula, a wire loop, a horn spoon, a curette, a cystotome, capsule forceps, a pair of scissors, iris forceps, iris scissors (see Fig. 183), and the cataract knife.

The following lotions and dressings should be at hand: Atropine drops (4 grains to the ounce), eserine drops ($\frac{1}{2}$ grain to the ounce), cocaine solution (4 per cent.), saturated solution of boracic acid, two solutions of bichloride of mercury (1-5000 and 1-10,000), Panas's solution,[1] and boiled distilled water containing $\frac{1}{2}$ per cent. of chloride of sodium. Suitable bulb syringes are to be provided.

For the purpose of dressings the following may be needed: Several rollers, two inches wide and five yards long, made of

[1] Panas's fluid contains the following ingredients:—

Biniodide of mercury	$\frac{3}{4}$ grain.
Absolute alcohol	6 drachms.
Distilled water	1 quart.

The biniodide of mercury should be dissolved in the alcohol, the water then added, and the whole well shaken.

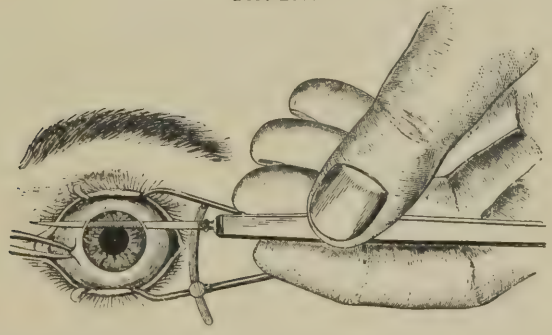
sterilized gauze, or, if a wet dressing is preferred, of gauze soaking in a bichloride solution; two or three flannel rollers of the same size as the antiseptic bandage; and antiseptic lint.

Everything being in readiness, the operation may be performed as follows:—

The surgeon, if he is ambidextrous, may stand behind the patient, no matter which eye is to be operated upon; if he is not, he should take this position for the right eye only, standing at the patient's side and in front, for an operation on the left eye. Again, if the surgeon is ambidextrous, he may stand in front and at the patient's right side for an operation upon the right eye, and at the patient's left side and in front, for an operation on the left eye.

The form of section having been previously determined, and the speculum having been inserted, the surgeon steadies the eyeball and draws it downward with the fixation forceps (it is supposed that the section is being made upward), by taking hold of a fold of conjunctiva below the inferior border of the cornea, the puncture and counter-puncture are effected, the knife is pushed steadily forward as far as

Fig. 205.



The incision in cataract extraction (Juler). Puncture and counter-puncture have been made. The incision should be completed in the line marked by dots. This incision is placed within the sclera and 3 mm. below the upper tangent of the cornea in this diagram, but it serves equally well to illustrate the general position of the knife according to the methods in which the incision is made in the corneal margin.

possible, with an upward tendency, and the incision is completed by gentle to and fro movements, keeping the edge of the knife well upon the border of the cornea until the summit is reached, when it is turned a little forward and the flap completed, unless it is desired to make a conjunctival flap when the direction remains a little upward. This completes the *first stage*. (Fig. 205.)

In the *second stage*, or the stage of iridectomy, the fixation forceps are intrusted to the assistant (trained to hand the instruments in their proper order) who gently draws the eyeball downward, while the operator takes in his left hand the iris forceps and in his right the iris scissors. If the iris is already protruding in the wound, a small portion of it may be seized and snipped off with a single cut, close to the border of the cornea. If not, the blades of the instrument must be introduced in the manner already described under iridectomy, and the pupillary border of the iris seized, the tissue drawn out and cut off with two snips of the scissors close to the cornea. It is not necessary to make a large coloboma. This completes the *second stage* (see Fig. 186).

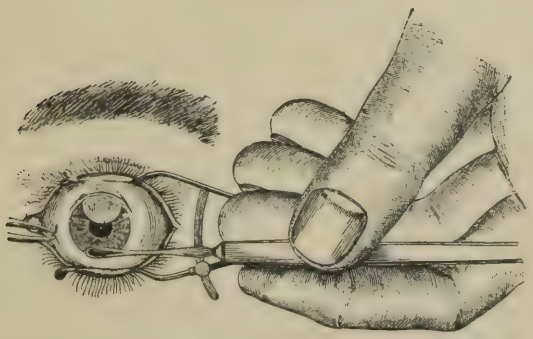
In the *third stage*, or the stage of capsulotomy, the operator takes in one hand the fixation forceps and gently steadies the eyeball, while with the other he introduces the cystotome, held flatwise during its insertion, and then turned with its cutting edge towards the capsule. This he now proceeds to cut, not tear, and without pressure lest the lens be dislocated. Operators differ in regard to the method of opening the capsule. This may be done by making a transverse incision from the centre of which proceeds a long vertical cut, or two cuts inclined to each other like the limbs of the inverted letter A, together with a transverse cut at the periphery may be made, or finally, as recommended by Knapp, the capsule may be opened in its extreme periphery with the understanding that later on the necessity for the operation for after-cataract will arise. Some surgeons open the capsule with capsule forceps, as a rule ; others prefer to use this instrument only in cases in which the anterior surface of the capsule is thickened. In withdrawing the cystotome the operator should again turn it flat-wise and be careful not to drag any tags of capsule into the wound. This completes the *third stage.*

In the *fourth stage*, or that of delivery of the cataract, the operator draws the eye slightly downward, or, if he has a docile patient, causes him to look downward. The back of a curette or the convex surface of the horn spoon is now laid against the inferior portion of the cornea, and firm, but at the same time gentle pressure is made, causing the upper margin of the lens to appear in the wound. The pressure is now exercised with an upward motion to coax out the cataract, but is relaxed as soon as the major portion has been expelled, in order that no undue tension be put upon the zonula. As the cataract slips through the wound the spoon is made to follow it and catch it, when it is lifted out with a little sweeping motion which may at the same time remove any small fragments of the cortex which have broken off and lie at the margins of the incision. This completes the *fourth stage.* (Fig. 205.)

In the *fifth stage*, or that which is now called the " toilet of the wound," after the eye has been allowed to remain closed for a few moments, the

operator cautiously inspects the wound. In this inspection he should ascertain whether the pupil is clear or whether any cortical remnants are present. If cortical matter remains it should be removed by the following manœuvre: The eye being turned downward, the operator makes

Fig. 206.



The delivery of the lens (Juler). The lens is presenting in the wound (capsulotomy has been performed).

a gentle rubbing movement in an upward direction on the cornea with the lower lid, great care being taken not to press too hard lest vitreous escape. Sometimes by rubbing gently in a circular manner cortical particles will be made to gather in the upper part of the wound, and then, while the rubbing is continued, the lips of the wound may be gently separated with a spatula and the expulsion of the cortical remnants effected. Blood-clot, the result of hemorrhage during the incision of the iris, may be expelled in like manner. If these directions, which are usually recommended, are followed, considerable care is necessary lest the margin of the lid come in contact with the wound and cause infection. It is not wise to make prolonged manipulation in this cleansing process.

Some surgeons have advocated the procedure which is known as *Irrigation of the anterior chamber*, which, as has already been stated, is used also in the operation of unripe cataract. In this the tip of a specially devised syringe is introduced between the lips of the wound and the irrigating liquid injected, which then causes blood-clot or cortical matter to be washed out. If irrigation is employed, two cautions are necessary: (*a*) No strong antiseptic solution should be used; certainly never bichloride of mercury, which is liable to produce indelible staining of the cornea. If any liquid which deserves the name of an antiseptic is employed, Panas's fluid may be tried, but even this is better replaced by boiled distilled water containing a half per cent. of the chloride of sodium. (*b*) In passing the liquid from the syringe into the anterior chamber, the direction of the flow should be over the

wound from within outward, and not the reverse lest particles of blood and cortex be driven inward. This caution Dr. Knapp especially dwells upon.

The angles of the coloboma should be carefully examined to see that there is no prolapse of the iris, and in any event, it is wise to introduce a delicate horn spatula, and smooth out the corners of the incision, inspecting the lips of the wound at the same time for tags of capsule.

A general inspection of the conjunctival sac should now be made; sometimes a little blood clot or a cilium may be present. In wiping away any clots, delicate pieces of sterilized gauze are very suitable, or the clots may be picked up with the iris forceps. If all of these manipulations have been successfully performed, the conjunctival cul-de-sac will be free from foreign matters, the edges of the wound nicely coapted, the pillars of the coloboma as straight as possible, and the angles not caught in the margins of the wound, the pupil black, and the patient readily able to count fingers. This completes the *fifth stage.*

The *sixth*, or final stage, is the application of the dressing. Much difference of opinion exists upon this subject. Some operators simply close the lids with a strip of isinglass plaster, while others place upon them an elaborate bandage. The following dressing is comfortable to the patient, namely, an oval piece of soft antiseptic lint laid upon each closed eyelid; over this a similarly shaped piece of sterilized cotton, large enough to be flush with the eyebrow and the lower margin of the orbit, and over this, in the form of a double figure-of-8, the turns of a sterilized gauze bandage. The bandage is meant to keep the dressing in place, but not to make pressure. The patient is then put to bed in a comfortable position in a slightly darkened room.

After Treatment.—For the first few hours, the effects of the cocaine having passed away, there are some smarting and burning, but severe pain should not occur. If at the end of twenty-four hours there has been no discomfort, no headache, and nothing to indicate that any anomaly in the course of healing is going on, the bandages need not be removed; but if they have become disarranged, or the patient has been uncomfortable, they should be taken off and the lids inspected. A little staining of the strip of lint is of no consequence, and if the eyelids are not swollen, and there is no discharge, and the delicate veins in the skin of the lids show no distension, the eyelids need not be opened, and the bandage may be reapplied; or the lower lid may be gently drawn downwards so as to permit the escape of tears which may

have accumulated in the conjunctival cul-de-sac, or to liberate the eye-lashes, if they have become inverted. At the end of forty-eight or seventy-two hours, the wound may be inspected by candle-light and each succeeding day the usual dressing reapplied; at the end of a week, the bandage may be removed, or, at least, a lighter dressing substituted, and at the end of ten or twelve days the patient needs only a shade and dark glasses. Although some operators do not require cataract patients to go to bed at all, it seems to the author that it is safer to keep them in bed for three or four days. The recumbent posture too long maintained may lead to hypostatic congestion of the lungs. Sometimes old people are very uncomfortable when confined to bed, and become slightly delirious; under these circumstances they may be allowed to rest in an easy chair. Some surgeons advise that the hands of the patient should be tied during the first night or two. For a few days liquid food, or at least food which does not require much chewing, should be given; after this, the ordinary diet suited to the case is permissible.

Accidents.—The following accidents may occur during the performance of a cataract extraction:—

(1) The knife may be introduced with the cutting edge turned in the wrong direction. If this somewhat inexcusable mistake should occur, the knife must be withdrawn and properly inserted. If this cannot be done, owing to the escape of the aqueous, postponement of the operation until the anterior chamber has refilled is necessary.

(2) The conjunctiva in the neighborhood of the counter-puncture may become distended with aqueous humor. This produces an elevation resembling a bleb. The section should be completed as if the accident had not happened.

(3) The iris may fall before the knife. The incision should be completed in the ordinary way. An irregular coloboma will result, which may be remedied by seizing the jagged edges with the iris forceps and trimming them with the scissors.

(4) Free hemorrhage may occur if a conjunctival flap is made, or in performing the iridectomy. The operator should stop, place upon the eye a piece of lint soaked in perfectly cold boracic acid solution, under the influence of which the bleeding will

sometimes cease, and he should then endeavor to get rid of the blood in the manner already described. If success does not follow the manœuvre, the cystotome must be introduced—even though everything is obscured by the blood—the capsule lacerated, and the lens expelled. During its expulsion, sufficient blood will often come away to clear the pupillary space.

(5) The wound may be too small. This is a very unfortunate occurrence, and can be remedied only by enlarging the incision, which is best done with a small pair of probe-pointed scissors.

(6) Undue pressure of the cystotome may cause the lens to be partially or completely dislocated. If the dislocation is partial, the eyes should be closed, and gentle pressure should be made with a bandage, when the lens probably will right itself and can be delivered. If the dislocation is complete, and the lens slips back into the vitreous, it must be removed by means of the scoop or wire loop.

(7) The vitreous may escape before or after the expulsion of the lens. If, before the expulsion of the lens, the operator should at once remove the cataract with the wire loop, which is gently inserted behind the lens. At the same time all pressure upon the eye must be removed. If vitreous escapes after the lens has been extracted, the wound should be cleared of protruding vitreous as gently and rapidly as possible and a bandage applied. Although escape of vitreous is an undesirable accident, its consequences are not always serious, and good visual results may be obtained. Occasionally the corneal flap is everted because it has been caught by the margin of the lid, owing to a sudden movement of the patient. It must be replaced, and a bandage quickly applied.

(8) Capsulotomy may not have been sufficient and pressure upon the inferior half of the cornea fails to cause the lens to present. In such a case the cystotome must be reintroduced and the laceration enlarged, or if the obstruction is due to the presence of a tenacious centre in the capsule, this may be excised with capsule forceps.

Anomalies in the Healing Process.—1. *Pain.*—Should pain occur and not be due to the circumstances already mentioned, but become violent in character, either in the earlier stages after the

operation, or some days afterwards, one of three things may be apprehended: Intraocular hemorrhage, suppuration of the wound, or iritis.

Intraocular Hemorrhage.—This is a most distressing accident, and presages loss of the eye. Usually, soon after the operation has been completed, the patient complains of very severe pain, or vomiting may occur and the dressings begin to be stained with blood. On removal of the bandage a clot of blood will be found protruding through the palpebral fissure, and on raising the lid the anterior chamber is seen to be full of blood and the corneal wound gaping widely. As a rule the cases terminate in suppuration and panophthalmitis. In the opinion of some surgeons enucleation should be performed. Dr. Knapp, however, advises that the blood should be carefully removed, the conjunctival sac washed out with a weak bichloride solution, the outside of the lid sterilized, and a full antiseptic dressing applied. The dressings should be changed once or twice daily. In this way it may be possible to avert suppuration, even though the eye remains blind. If the hemorrhage should continue and the pain become intense, enucleation is necessary.

Suppuration of the Wound.—Great care in antiseptic details has rendered this accident rare at the present time. According to Collins, it is more common in old people than in young, and the tendency is greater between 60 and 70 than between 70 and 80, though it is certainly greater between 80 and 90 than between 60 and 70. Suppuration has no relation to the time of year at which the operation is performed. It may be caused by lachrymal complication, microbic inflammation of the upper respiratory tracts, conjunctivitis and blepharitis, by infection introduced at the time of the operation, and finally by want of sufficient nutrition in the cornea. Suppuration commences on the first, second, or third day, more rarely on or after the fifth day, but sometimes as late as the thirteenth day.

The symptoms are pain, swelling of the lids, chemosis of the conjunctiva with undue secretion, haziness of the cornea, turbidity of the aqueous and the formation of a slough along the margins of the wound.

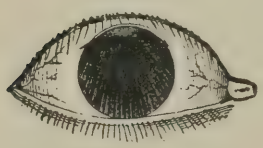
Two terminations are possible: The suppurative process may be limited, so that at the end of the inflammation the pupil is closed and the iris drawn upward, or the entire globe may participate in a general destructive inflammation (purulent panophthalmitis).

Prompt treatment may be of avail. The conjunctival cul-de-sac should be carefully disinfected, the lips of the wound gently parted after removal of the slough, and irrigated with a bichloride solution, and the whole line of the incision freely cauterized with the actual cautery. In other words the treatment is practically that which has been advised for a sloughing ulcer. Internally, quinine, iron and milk punch should be exhibited, and opium at night.

Iritis.—The symptoms generally set in about the fifth day, but in a number of instances may be delayed to the tenth day. Iritis is generally caused by an imperfect toilet of the wound, but may sometimes be called into existence by too early exposure of the eye.

The *treatment* should be leeches to the temple, the free use of atropine, warm fomentations, and the internal administration of full doses of quinine and small doses of mercury.

Fig. 207.



The appearance of an eye in which the pupil has been occluded and misplaced by iritis after cataract extraction (Nettleship).

Bulging Cicatrix.—Instead of perfectly smooth healing, the cicatrix, at the end of a week or two, may begin to bulge, sometimes at one or other extremity of the wound, and sometimes through its entire length. The bulging consists in a vesicle-like, semi-transparent elevation, and is generally associated with an entanglement of the iris in its margins, together with distortion of the coloboma. Eyes in which such entanglement of the iris has taken place are likely to develop irido-keratitis.

The complication, which has been termed *glaucoma after extraction*, occurs after a severe iritis, with numerous posterior synechiæ, which has led to the formation of a membrane. It may occur after the iritis, which is characterized by a deep anterior chamber and dotted opacities on the cornea, or also when the iritis is only

slight in character, but when there has been an adherence of the pillars of the coloboma to the cicatrix and also to the lens capsule. This tends to obliterate the canal of Schlemm.

Opacities of the Cornea and Keratitis.—Opacity in the cornea almost invariably is due to the injection of antiseptic fluid, especially strong solutions of bichloride of mercury, into the anterior chamber. It has a peculiar milky white appearance, and is located chiefly at the posterior surface of the cornea, although the epithelium may also be rough. It does not disappear, and if sufficiently thick entirely vitiates the effect of the operation. This opacity must not be confounded with a very common type of keratitis occurring after cataract extractions, which has received the name *striated keratitis*, consisting of fine stripes of opacity radiating in several directions across the cornea. This entirely disappears in a few days, and need not give rise to apprehension.

Extraction without Iridectomy.—At the present time numerous operators of vast experience have returned to what is now known as *simple extraction*, or, in other words, an *extraction without iridectomy*. This was the practice in the old flap operation, and was abandoned, together with this form of incision, owing to the numerous failures from sloughing of the cornea. Under the modern methods of antisepsis, and especially with the aid of cocaine, and, in the opinion of some surgeons, of eserine (which is instilled at the close of the operation), there has been a return to a modified flap method, in which the operation is performed in general terms like the one which has just been explained, save only that iridectomy is omitted. The section is made in the clear cornea, close to the limbus, parallel to the corneal margin. According to the size of the cornea and of the lens, the section must include nearly or entirely one-half of the corneal circumference, and must be kept well in front of the plane of the iris, otherwise this structure will prolapse.

Obviously the advantages of this operation, if it is successful, are the absence of mutilation of the iris, and consequently the formation of a round pupil which reacts freely to the changes of light and shade and prevents the dazzling so often caused by the presence of a coloboma. Its disadvantages are the difficulty of expelling the lens (which should be effected in the usual manner,

aided by pressure with a small spatula upon the ciliary region), the increased difficulty of performing perfect toilet of the wound, and the danger of prolapse of the iris. In the hands of operators of great experience the first two objections have little weight, and the tendency is to return to this mode of operating, Dr. Knapp stating that he does not think he shall ever cease to, practise simple extraction. Certain cases will always require iridectomy, especially those in which the ball is hard, the lens is large, and any other complications exist which are likely to place decided obstacles in the road of this method.

Preliminary Iridectomy.—Some operators, almost as a rule, perform a preliminary iridectomy and extract several weeks later, believing that this lessens the dangers of extraction. It is to be recommended in any case where serious complications are apprehended, or where for any reason an extraction in one eye has terminated unfavorably.

Operations for After-Cataract.—After-cataract, or, as it is usually called, secondary cataract, has been described. If it is a delicate web-like membrane which stretches across the pupil, and which is best seen by the oblique method of illumination, the treatment is simple, and consists in the introduction of a cataract needle or a Hays knife-needle, in the manner described under DISCISSION, and making a laceration in the membrane. When, however, the opacity is a thick one, and there has been much proliferation of the epithelium, this simple procedure, owing to the dense and resisting character of the tissues and the danger of dragging upon the ciliary body and iris, is not sufficient. It is then best to introduce two needles at the opposite sides of the cornea, one serving to fix the membrane while laceration is effected with the other. The needles may have a shoulder and are known as stop needles, and the method as *Bowman's operation.* The method of the introduction of the needles, and the manner of approximating their handles so as to cause a rent in the tissue, can be seen from an examination of Fig. 193.

Other plans are to divide the capsule with delicate canula scissors, or to perforate the cornea and fix the membrane with a broad needle, and then with a sharp hook introduced through a corneal opening at the opposite margin, to tear and roll up the

membrane, which, if not too closely attached, may be drawn out with the instrument and cut away. The latter is the method of the late Dr. C. R. Agnew.

Discission is an operation invested with a great many dangers. Under no circumstances should there be rough handling; the discission instruments must be very sharp, and the operator must avoid dragging upon resisting bands. Preceding the operation and following it there should be the free use of atropine. If signs of reaction occur, leeches and the treatment of iritis are indicated. In cases of occlusion of the pupil by a drawing up of the iris, or where there are bands of strong inflammatory lymph, to which also the name secondary cataract is sometimes applied, discission is not advisable. In most instances, iridotomy (page 593) is the best operation.

Operations upon the Eye Muscles.

These consist of *complete* and *partial tenotomy*, and *advancement* or *readjustment*. For the operation of tenotomy the following instruments are required: A stop speculum or lid elevator, two strabismus hooks, fixation forceps, and a pair of probe-pointed scissors, the form devised by Dr. Jackson being particularly suitable. (Figs. 208, 209.) In young children general anæsthesia is advisable; in adults cocaine is sufficient. Usually the internal rectus is divided; quite frequently the external rectus; less commonly the other straight muscles. In a tenotomy on the internal rectus, for example, the operator proceeds as follows:—

Figs. 208, 209.



Strabismus hooks.

The eyelids being separated with a stop speculum, the surgeon catches with a fine-toothed forceps a fold of conjunctiva and subjacent fascia on a level with the lower border of the tendon, and with the probe-pointed scissors makes an opening just large enough to admit the strabismus hook. He may with one clip divide conjunctiva, subjacent fascia, and the capsule of Tenon; otherwise, after the division of the conjunctiva and subconjunctival tissue, Tenon's capsule must be picked up and incised in a length equal to

the cut made in the overlying structures. The scissors are now laid down, and with his right hand the operator takes the strabismus hook and insinuates it behind the tendon, the wound at the same time being held open with the forceps. After insertion the hook is pressed firmly against the sclerotic, and pushed between this and the tendon as far as the elbow of the instrument will permit. The point is then turned upward and made to appear at the outer border of the tendon beneath the conjunctiva. It is now drawn forwards and outwards towards the cornea, and will be stopped by the insertion of the tendon. The operator now dispenses with the forceps, takes the hook in his left hand, renders the tendon tense, introduces the scissors, with their blades slightly parted, into the wound between the hook and the eye, and divides the tendon close to its sclerotic attachment by a number of slight cuts. After the section has been performed the hook should be swept through the opening in order to catch any strands which may have escaped the scissors. These should then be divided. This is the *subconjunctival operation*, and was introduced by Critchett.

After washing out the eye with solution of bichloride of mercury a light bandage may be applied for a day or two.

Instead of using the subconjunctival method, especially in cases where there is a considerable squint, the open operation, or as it is known the Graefe method, may be performed as follows :—

The stop speculum having been introduced, the operator seizes a fold of conjunctiva over the insertion of the tendon, that is about 5 mm. from the margin of the cornea, and makes a transverse incision. Tenon's capsule is now opened and the hook passed beneath the tendon, which is then entirely divided. The surgeon can increase the effect of the operation by incising more or less freely the subconjunctival fascia, and thus allowing greater or less retraction of the tendon ; and also by dividing the fascia above and below the tendon, cutting upward and downward after the tendon itself has been separated from the sclerotic. On the other hand, he may diminish the effect of the operation, if it is necessary, by inserting one or more conjunctival stitches.

In tenotomy of the externus the tissues may be incised more freely than in one of the internus. The effect upon a divergent squint may be increased by drawing the eyes toward the nose with sutures (Gruening).

Complications.—(1) The operator may fail to have divided the capsule of Tenon. Under these circumstances he will also fail to introduce the hook beneath the tendon, and by such failure will recognize that he has not sufficiently incised the tissues.

(2) Occasionally severe hemorrhage follows a tenotomy, the blood rapidly pouring out beneath the capsule of Tenon, and causing alarming proptosis. The pressure of the escaped blood may produce atrophy of the optic nerve. This accident is attributed to rupture of one of the ciliary arteries, and is less liable to occur in the Graefe method than in the subconjunctival operation. A firm pressure bandage should be applied, and gradually the proptosis will subside and the blood become absorbed.

(3) *Orbital Cellulitis and Tenonitis.*—Cellulitis occurs from infection of the wound, the inflammation travelling back and causing an inflammation of the tissues of the orbit. Such an accident may be the result of an uncleanly operation. The treatment of orbital cellulitis described in another section is applicable. Tenonitis, or inflammation of the orbito-ocular fascia, has followed squint operations.

(4) *Perforation of the Sclera.*—Although this is a rare accident, it has happened to operators of considerable experience. It is difficult to understand why it should occur unless sharp-pointed scissors were used, and for this reason the probe-pointed instrument is always to be preferred.

(5) *Retraction of the Caruncle*, so that it sinks away from its normal position and gives a most disagreeable and peculiar stare to the eye, is a very unfortunate occurrence after a squint operation. A very slight degree of this is liable to occur even after the most careful tenotomy. When it exists in great degree, it is due in part to excessive dissection of the tissues and in part to retraction of the muscle. There are several methods of overcoming this defect, the essential character of which is the loosening up of the contracted tissues and stitching the caruncle into place.

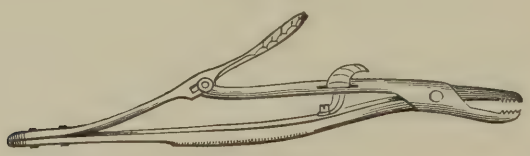
In convergent strabismus of high degree it is usually necessary to perform tenotomy upon both internal recti, sometimes, as explained later on, associated with advancement of the externus. Operators differ as to whether both tenotomies should be done simultaneously, many preferring—and this seems to the author to be the safer rule—to wait and see what the effect of the first operation will be before the second is undertaken.

Partial or Graduated Tenotomy.—Graduated tenotomies are performed for the purpose of correcting those conditions which are described under insufficiencies of the ocular muscles, when it is not deemed wise to perform a complete section of the tendon. The method has been especially elaborated by Dr. Stevens, of New York, and is done as follows :—

With a pair of small, narrow-bladed scissors a transverse incision is made through the conjunctiva, exactly corresponding to the line of insertion of the tendon. This is seized behind, but near its insertion, and a small opening is made dividing the centre of the tendinous expansion exactly on the sclera. This opening is then enlarged by careful cuts with the scissors towards each edge, keeping carefully on the sclera as the border of the tendon is approached ; the amount to be cut depends upon the judgment of the operator and the need of the case, and is further regulated by placing the patient before a lighted candle and testing the sufficiency of the muscle upon which the operation is made, in the manner already described in connection with the investigation of heterophoria.

Advancement or Readjustment is an operation in which the tendon of a rectus muscle is brought forward to a new attachment. The operation is applicable to cases in which the tendon has become weakened—as, for instance, in myopia, together with the production of divergent squint—to those cases of convergent strabismus in which it is desirable to combine advancement of the external rectus with tenotomy of the internus, and to cases in which an injudicious division of the internal rectus, for instance, has converted a convergent into a divergent squint. The operation is somewhat tedious and painful, and general anæsthesia is advisable.

Fig. 210.



Needle-holder.

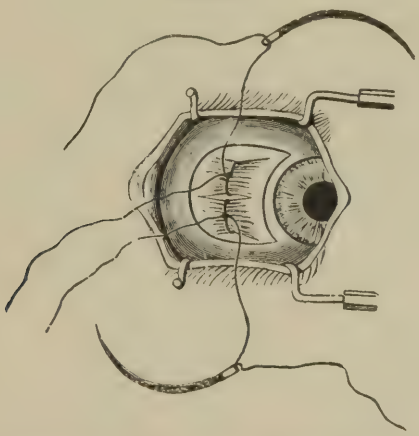
The same instruments which are used in tenotomy are required, in addition to which suitable curved needles, a needle-holder (Fig. 210), silk thread, fine catgut, and advancement

forceps should be provided. There are numerous methods of performing advancement. One will be described :—

(1) The insertion of the tendon is exposed and the strip of conjunctiva between the opening and the cornea detached from the sclera. A hook is then inserted beneath the tendon and brought well up to its insertion. A needle threaded with fine catgut or silk is next inserted from the upper margin of the tendon between this and the sclera, and passed through the tendon at its middle line. Similarly, another suture is passed behind the tendon from its lower margin close to the first. Each of these is firmly knotted, a long end being left. The tendon is now separated with scissors and the sutures are passed through the conjunctival flap in the direction of the muscle, and are tied with their own ends. An antiseptic dressing is applied ; the sutures are removed on the fourth or sixth day, according to circumstances.

This very simple and satisfactory method is recommended by Mr. Swanzy, and is one with which the author has had gratifying results.

Fig. 211.



Advancement of the external rectus (Swanzy).

In A. E. Prince's operation, an unyielding anterior fixation-point is obtained by utilizing the dense episcleral tissue, securing the muscle, and regulating the effect by a skilfully devised "pulley-suture." In Schweigger's method, a free exposure of the muscle is made, and after the tendon is divided, a portion of the

end is resected; catgut sutures are employed to advance the muscle.

Advancement of the capsule of Tenon, the tendon being folded on itself, has been practised by several surgeons (Wecker, Knapp).

Operations upon the Lachrymal Apparatus.

Slitting the Canaliculus.—This is performed as follows:—

Fig. 212.



Weber's canaliculus knife.

The lid being drawn down and out with the thumb, and the canaliculus knife held vertically, the probe point is introduced into the punc-

Fig. 213.

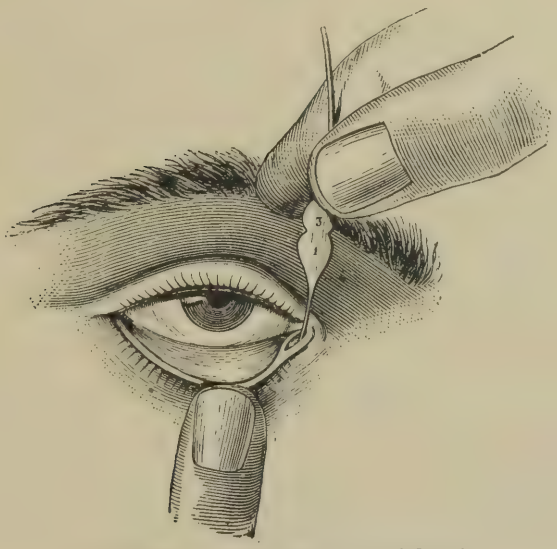


Introduction of the knife into the canaliculus (Berry).

tum. The handle is now depressed into the horizontal position and the instrument pushed along the canal until the probe point touches the inner wall of the lachrymal sac. It is then raised to the vertical line with the cutting blade turned slightly inward and the roof of the canaliculus divided. Either the upper or the lower canaliculus may be slit.

Introduction of a Lachrymal Probe.—The probe (Bowman's probes are commonly employed, though useful modifications have been devised by Theobald and Tansley) is introduced by passing it horizontally along the canaliculus until its point touches the lachrymal bone. It is raised to the vertical position and pushed

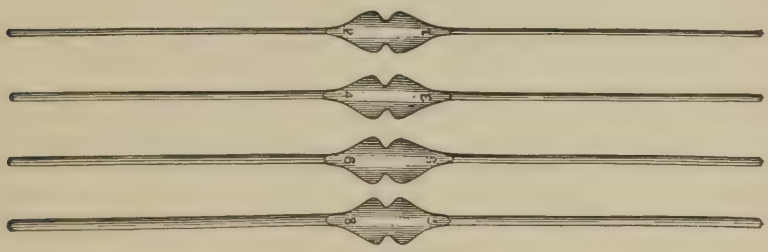
Fig. 214.



Introduction of a lachrymal probe (Meyer).

into the duct, remembering that the direction should be downward, slightly backward, and outward. (Fig. 214.)

Fig. 215.



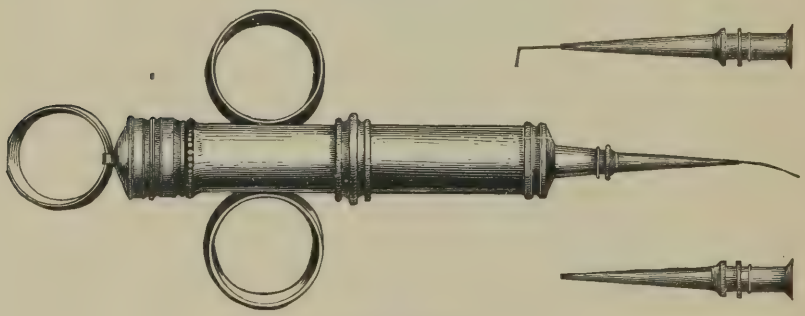
Lachrymal probes.

Incision of a Stricture.—If the stricture resists, it may be divided with a knife, either the one which has been employed

in slitting the canaliculus, or, still better, with the instrument of Stilling. The knife is introduced in the same way as the probe, pushed down into the duct, and the stricture incised. The knife is then partially withdrawn, turned slightly, and the manœuvre repeated.

Introduction of a Lachrymal Syringe.—The nozzle of an Anel syringe can be introduced along the canaliculus without slitting it. The lid is drawn down and outward in the same manner as if the operation of slitting were to be performed and the point of the syringe introduced. Sometimes the punctum is swollen shut and the nozzle cannot be inserted. Under these circumstances the punctum may be dilated with a silver pin. Ordinarily a lachrymal syringe is furnished with a canula probe. This is introduced into the duct in precisely the same manner as the solid probe, the syringe is filled with an antiseptic fluid, inserted into the mouth of the canula, and the liquid injected into the duct.

Fig. 216.



Anel syringe.

In severe cases of epiphora excision of the lachrymal gland has been recommended, which is performed by making an incision below the upper and outer third of the orbital ridge, cautiously opening the orbit, seizing the gland with a double hook, and carefully dissecting it from its attachments; hemorrhage having been controlled, the wound is closed with sutures. Instead of excising the whole gland the palpebral portion may be removed. In obstinate cases of lachrymal disease some operators have excised the anterior wall of the sac, or have entirely obliterated it by the use of caustics or with galvano-cautery applied through an incision in the wall of the sac.

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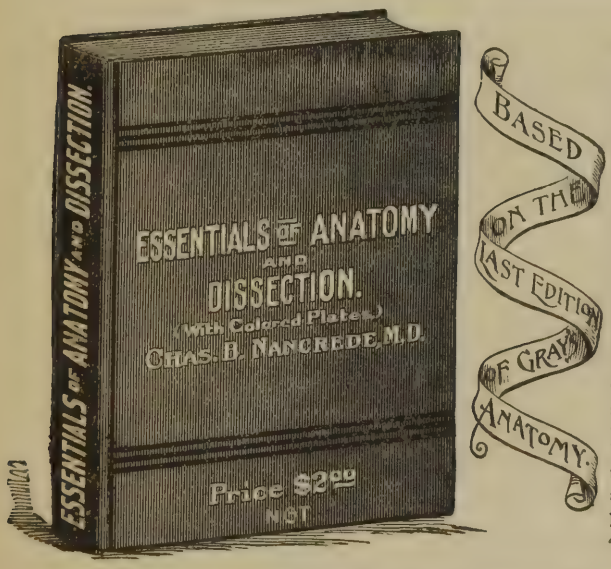
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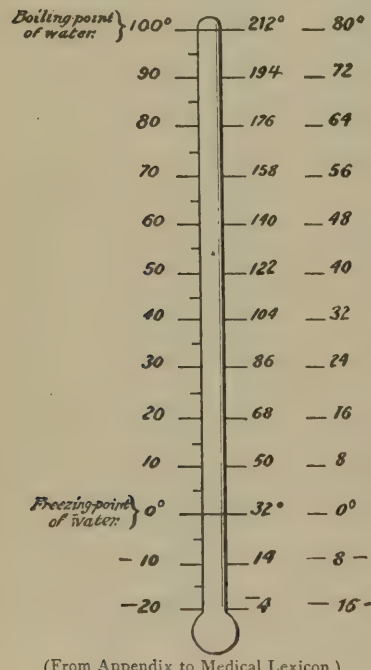
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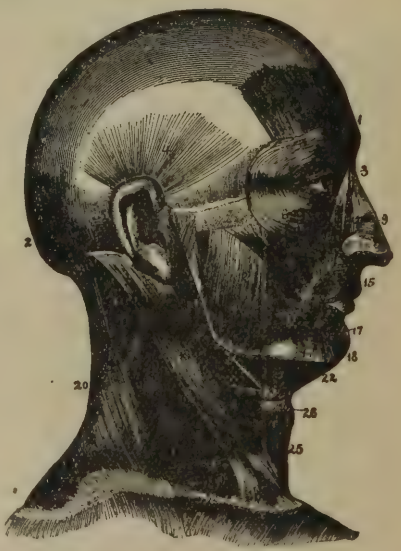
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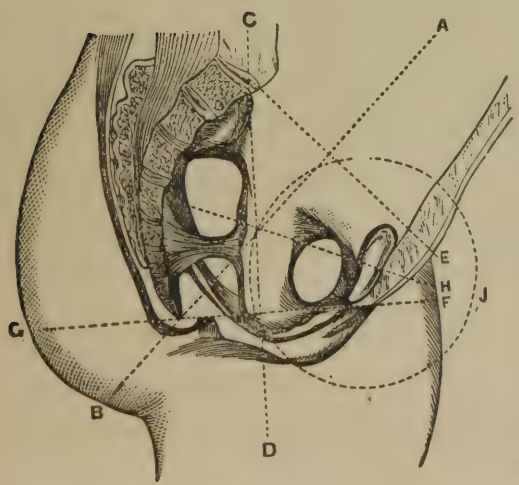
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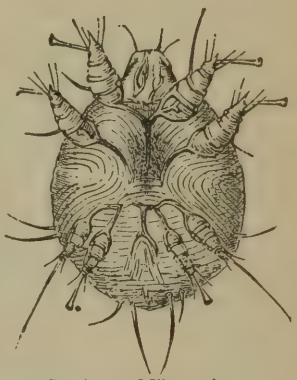
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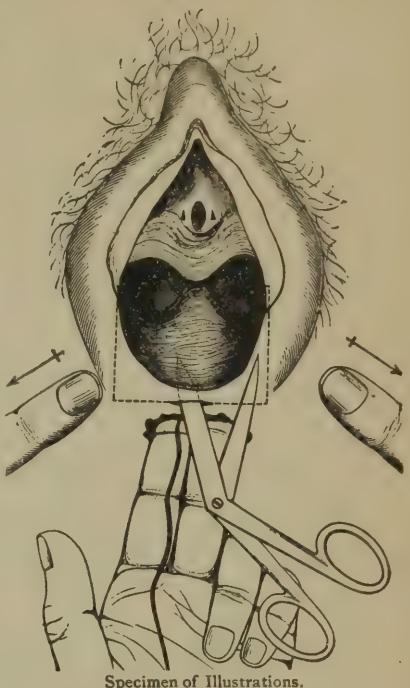
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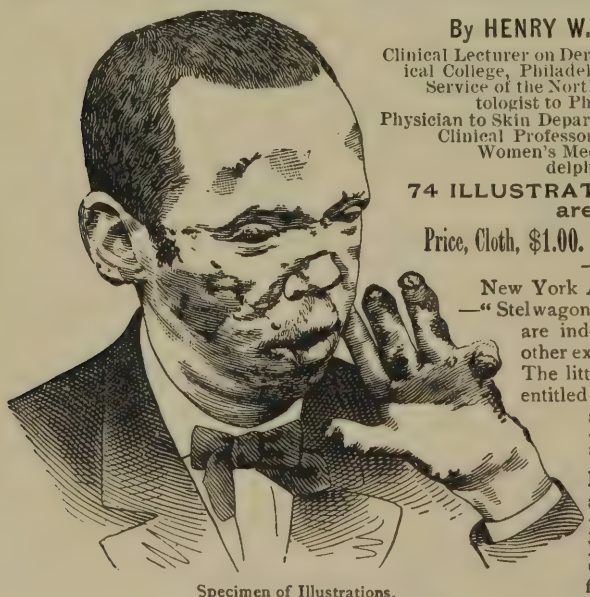
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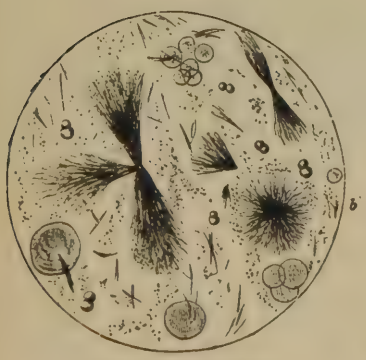
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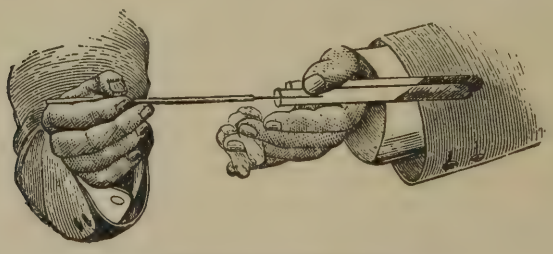
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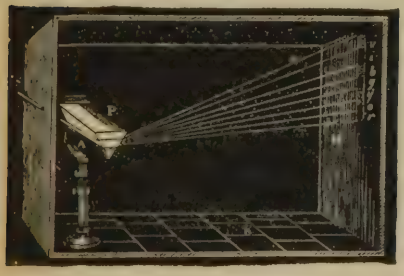
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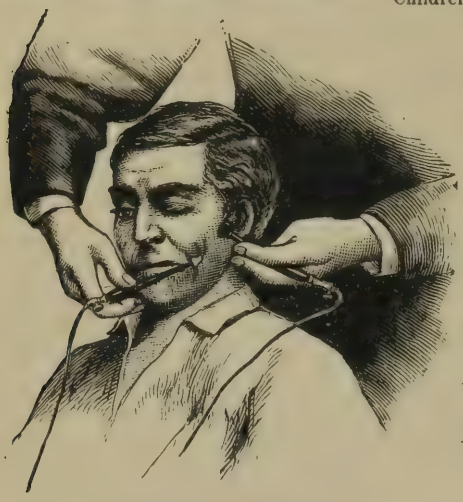
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